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## SYNTHETIC RUBBER

By E. R. GILLILAND

By occupying the Malay Peninsula and the islands of the southwest Pacific Ocean, the Japanese precipitated a serious problem for this country because most of its rubber has come from that region. Directly or indirectly, rubber vitally affects nearly every aspect of our lives. To have the source of its supply suddenly cut off was almost disastrous.

It was very fortunate that an extended research and development program on making rubber or a material having similar physical and chemical properties had been carried on by scientists of various educational and commercial institutions. The development of new rubber plantations requires several years even when suitable tropical areas are available. The tropical areas of Central and South America are not well adapted to the development of such plantations because of certain plant diseases that, in those areas, attack the present type of rubber trees. It is probable that trees resistant to those diseases can be developed, but such a program would require a long experimental period.

### I

English and German chemists were the first to attempt to make rubber—true rubber, not some other substance having similar properties. In order to make a chemical compound the first step normally is to find the chemical elements—oxygen, hydrogen, carbon, etc.—of which it is composed. But this is not enough. It is necessary also to find how the elements are joined together. There are common examples of chemical compounds that are composed of precisely equal numbers of the same atoms, but which differ greatly in their properties.

The English and German chemists who were working on natural rubber easily found its constituent elements and concluded that those elements were joined together into a chemical compound called "isoprene," or groups of isoprene molecules linked together. At least, by suitable chemical treatment, natural rubber can be broken down to isoprene or to chains of isoprene molecules. It is likely, if not certain, that rubber owes its remarkable properties to long chains of molecules formed by the joining of isoprene or similar units. When a molecule joins with similar molecules to form a chain, the process is called polymerization. This type of reaction has become of primary importance, not only in the production of rubber but also throughout the petroleum and plastic industries and elsewhere in industrial chemistry.

A large amount of experimental work was carried out on the polymerization of isoprene. None of these experiments resulted in polymers having properties the same as those of natural rubber. This is not surprising when one considers the large number of ways in which isoprene can combine with itself. In fact, there are natural substances which can be considered polymers of isoprene just as much as rubber is, but which have considerably different characteristics; gutta-percha is one example.

This experimental work on the polymerization of isoprene was carried out in a period when the cost of rubber was high and before plantation rubber had really been developed. With the lowering of the cost of rubber, the incentive to develop such materials became

less. Another deterrent has been the difficult problem of obtaining isoprene of high purity. Isoprene can be produced by high temperature cracking of turpentine and, in very low yields, by high temperature cracking of petroleum compounds, but both processes give products that require further purification—a rather difficult problem.

Following this period, the emphasis has shifted almost completely from attempts to produce true rubber by synthetic processes to attempts to produce materials that have properties similar to those of natural rubber and which can be produced from easily obtainable raw materials. These rubber-like materials have inherited the appellation "synthetic rubber," and this term has become a generic name for the whole group.

In the "crude" state a good rubber-like material can be easily worked, molded and shaped, and then can be changed chemically into a strong, elastic material that will resist deformation. As a result of intensive studies, chemists concluded that those organic materials having elastic properties are composed of very long, thin molecules. The ratio of length to diameter of a fully extended molecule may be as great as several thousand to one. Such molecules in the unvulcanized, or uncured, form of rubber are presumably greatly contracted in length and interwoven with one another. When a mass of such material is molded or shaped by being subjected to pressure or stretching, its individual molecules are actually displaced relative to one another. If then, by chemical processes, these long chain molecules can be tied together, further displacement relative to one another becomes much more difficult and the material acquires the property of resisting forces that otherwise would cause permanent deformation. However, owing to the contracted condition of the molecules, the material can still be extended. In this process the molecules are simply pulled out somewhat like a spring without causing their rearrangement.

In natural rubber the vulcanizing, or knitting together, of the rubber structure is generally carried out by the addition of sulfur, although in special cases oxygen is used. The mechanism of this process is not definitely known, but it is believed that the chemically unsaturated rubber molecules combine with other molecules or atoms, such as sulfur, and form some type of bridge or connection between adjacent rubber molecules.

The chemists, therefore, directed their studies to the production of long chain molecules that have this unsaturation characteristic and that can be locked together by vulcanization or an equivalent process. In general, chemical substances that are readily available or that can be prepared easily, economically, and in high purity are low in molecular weight, but only those capable of combining to form long chains are useful for the production of rubber-like substances.

The class of compounds that most nearly fits these two requirements of combining to form long chains and of having residual chemical properties suitable for vulcanization are the diolefins. Olefin is a generic name for certain compounds of hydrogen and carbon that, because they are unsaturated, combine more or less easily with other materials. A diolefin has two groups having the olefin characteristic in the same molecule. One of these unsaturated groups can be employed to combine with other molecules to form the long chains, leaving the other unsaturated group for use in the cross-locking of molecules in the vulcanization step. The diolefin group comprises a large number of chemical compounds, but only a relatively few of them can be prepared easily and economically on a large scale. Isoprene is a member of the diolefin class which contains five carbon atoms to a molecule, but, as has been pointed out, this particular compound is somewhat difficult to prepare. Of all the diolefins, butadiene is perhaps the easiest to prepare, and for that reason has become the basic raw material of most of the current synthetic rubber production. It has four carbon atoms and six hydrogen atoms to the molecule. Another diolefin that is employed in the present Government program is chloroprene, a chlorinated butadiene. Dimethyl butadiene was employed by the Germans during World War I to prepare the so-called methyl rubber.

Butadiene can be polymerized in a number of ways, but for most uses it has been found advantageous to copolymerize it with other

organic molecules, such as styrene, acrylonitrile and the various acrylates. These materials can be made to react with butadiene during the polymerization, or chain forming, process. In other words, the long chain molecule is composed of a mixture of the two types of molecules, probably somewhat irregularly spaced. The addition of these materials gives an improved synthetic rubber often possessing very desirable special properties.

## II

The United States Government program includes the production of three types of synthetic rubber—Buna-S, Butyl, and Neoprene. For this program the products have been named GR-S, GR-I, and GR-M, respectively.

The annual rated capacities in long tons (2,240 pounds) of the rubber plants constructed and under construction in the United States and Canada are as follows:

| | |
|---|---|
| GR-S | 735,000 |
| GR-I | 75,000 |
| GR-M | 40,000 |

In addition, the annual production of privately owned plants will be as follows:

| | |
|---|---|
| Neoprene | 9,000 |
| Buna-N | 24,000 |

### Production of GR-S (Buna-S)

GR-S is the main synthetic rubber of the United States and Canadian programs. Plants under construction have a rated capacity when complete of 735,000 long tons per year, which is 86 percent of the expected total GR-S is a copolymer of butadiene and styrene and was chosen because it is a general purpose rubber that can replace natural rubber in most uses.

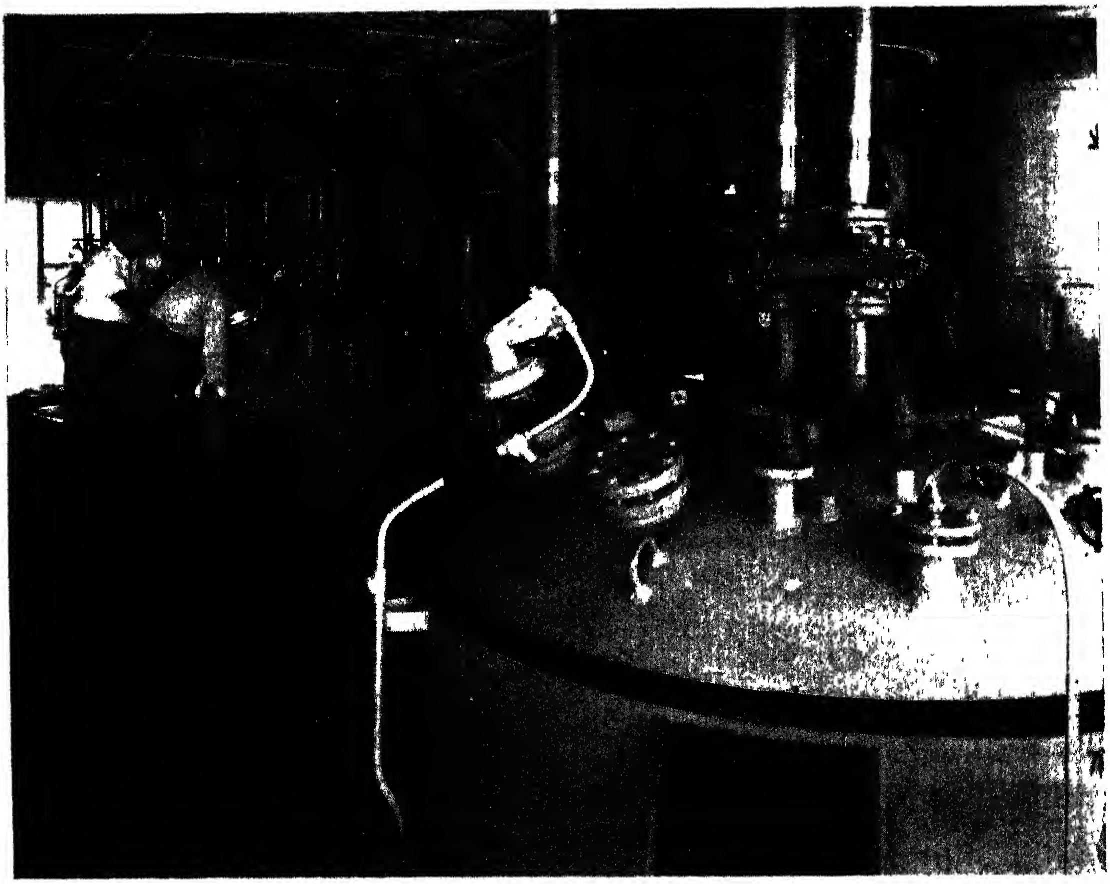
*Preparation of Raw Materials.* Butadiene, which constitutes the largest tonnage of raw material employed in the Government synthetic program, can be prepared from a large number of substances in a number of different ways. Actually, it is being made from each of the following four products: ethyl alcohol, butylene, butane, and gasoline and heavier petroleum products.

The reactants concerned in the first three cases are treated catalytically at relatively high temperatures and low pressures, and they give high yields of butadiene relative to the quantity of the starting material. Production from gasoline and oil requires a high temperature, low pressure thermal treatment in which the larger molecules are broken up with the production of a small percentage of butadiene and large quantities of other materials.

In the alcohol process, grain alcohol or ethyl alcohol from other sources is used to produce a butadiene fraction of relatively high purity. The equipment necessary for concentrating this fraction to high purity butadiene is relatively simple. This type of operation is carried out in three plants designed for the Government program by the Carbide and Carbon Chemical Corporation. These plants will produce 220,000 short tons of butadiene per year. The first, located at Institute, West Virginia, and having a rated annual capacity of 80,000 short tons has been completed for several months and is operating very successfully. The two other plants, located at Kobuta, Pennsylvania, and Louisville, Kentucky, and having rated annual capacities of 80,000 and 60,000 short tons, respectively, are now producing butadiene. The plants at Institute and Louisville are operated for the Government by the Carbide and Carbon Chemical Corporation, and the plant at Kobuta is operated by the Koppers-United Company.

A different type of process for producing butadiene from alcohol is being constructed by the Bigler Chemical Company, employing the so-called Publicker, or Szukiewicz, process. This alcohol process apparently is fairly similar to the method employed by the Russians for the production of essentially all their butadiene.

These alcohol processes produce from two to two and a half pounds of butadiene per gallon of 95 percent alcohol. In general, about 2 7 gallons of such alcohol can be produced per bushel of corn. In other words, one bushel of corn will produce between 5.5 and 6.8 pounds of butadiene. Therefore, by this type of operation, even high quality farm land would produce only enough grain per acre, per year, to make butadiene equivalent to approximately 350 pounds of synthetic rubber, which is substantially less than the 450 pounds of natural rubber that can be



TOP VIEW OF THE REACTORS IN THE STANDARD GR-S PLANT

produced per acre in the tropics. If wheat is employed for the production of butadiene, the quantity that can be produced per acre is only about one-third that obtainable from corn, but the percentage of the farm land of the United States suitable for wheat production is much greater than that for corn.

The plants employing the process for producing butadiene from butylenes have a total annual rated capacity of 292,000 short tons. The normal butylenes employed are a by-product of the refinery operations, such as catalytic and thermal cracking. Normal butylene differs from butadiene only in having two more hydrogen atoms per molecule. The procedure involves the removal of these two extra atoms by a process called dehydrogenation. The operation is carried out by contacting butylenes with a catalyst at high temperature. A portion of the butylenes is converted to butadiene, which is then removed and purified, while the unreacted

TABLE 1. Plants Scheduled for the Production of Butadiene from Butylenes

| *Operating company* | *Location* | *Annual capacity* |
|---|---|---|
| Standard Oil Co. of Louisiana | Baton Rouge, La. | 15,000 |
| Humble Oil & Refining Co. | Baytown, Tex. | 30,000 |
| Shell Chemical Co. | Torrance, Calif. | 12,000 |
| Neches Butane Products Co. | Port Neches, Tex. | 100,000 |
| Sinclair Rubber, Inc. | Houston, Tex. | 50,000 |
| Polymer Ltd. | Sarnia, Canada | 30,000 |
| Cities Service Refining Corp. | Lake Charles, La. | 55,000 |
| | | 292,000 |

butylenes are recycled for further conversion. Such a process produces about 2.7 pounds of butadiene per gallon of butylene.

The butylene dehydrogenation process, which will be used in seven plants scheduled for the United States and Canada, was developed by the Standard Oil Company of New Jersey. Table 1 lists the companies that will operate the plants for the Government,* together with their locations and annual rated capacities in short tons (2,000 pounds).

The plants at Baton Rouge and Baytown are in operation, and construction of most of the others is nearing completion.

The process for preparing butadiene from butane is somewhat similar to that employing butylene. Butane differs from butadiene in containing four more atoms of hydrogen per molecule, and it is, therefore, necessary to remove twice as much hydrogen as is necessary with butylene. The actual process is carried out similarly by a catalytic dehydrogenation operation at high temperatures involving either a one-stage or a two-stage process. In the one-stage operation a mixture of butane and butylene is passed over the catalyst and a portion is dehydrogenated to butadiene, while simultaneously a portion of the butane is converted to butylene. The butadiene is removed and concentrated, and the mixture of butylene and butane is recycled for further treatment with the addition of make-up butane. In the two-stage process, butane is dehydrogenated to butylene, which is separated from the unreacted butane and then further dehydrogenated to butadiene. The unreacted butane and butylenes are recycled in their respective steps.

The Government has scheduled a production of 75,000 short tons of butadiene a year by the butane process. Two plants are employing the so-called one-stage method, known as the Houdry process. Both have annual rated capacities of 15,000 short tons of butadiene. One of the plants will be operated by the Sun Oil Company at Toledo, Ohio, and the other by the Standard Oil Company of California at El Segundo, California. A plant employing the two-stage process is being operated by the Phillips Petroleum Company at Borger, Texas. This unit has an annual rated capacity of 45,000 short tons of butadiene

This type of operation produces about two pounds of butadiene per gallon of normal butane While the yields per gallon are lower than from butylene, normal butane is a raw material that is more available, being a constituent of the natural gas produced in various parts of the United States.

TABLE 2. PLANTS SCHEDULED FOR THE PRODUCTION OF BUTADIENE FROM PETROLEUM

| *Operating Company* | *Location* | *Annual capacity* |
|---|---|---|
| Southern Calif. Gas Co.-Shell Chemical Co. | Los Angeles<br>Torrance, Cal. | 30,000 |
| Standard Oil Co. of Louisiana | Baton Rouge, La. | 6,800 |
| Eastern States Petroleum Co. | Houston, Tex. | 12,800 |
| Humble Oil & Refining Co. | Ingleside, Tex. | 7,000 |
| Lion Oil & Refining Co. | El Dorado, Ark. | 6,700 |
| Taylor Oil & Refining Co. | Corpus Christi, Tex. | 5,500 |
| | | 68,800 |

The production of butadiene from gasoline and heavier petroleum fractions differs from the foregoing processes because butadiene is a relatively minor fraction of the total output. This thermal cracking process seldom produces more than six percent, by weight, of butadiene from the material charged. Besides butadiene, this method produces a large number of other valuable products, such as ethylene, propylene, butylenes, isoprene, piperylene, benzene, toluene, xylene, lighter gases and heavier residuals. If an integrated plant can be built to utilize a number of these by-products, this method will furnish a desirable process for the production of butadiene. If the by-products are not efficiently utilized, the process is feasible only as an emergency operation.

The petroleum fractions are vaporized and then treated at high temperatures either in a tubular furnace or in a regenerative type brick-work. The products, which contain

* The Polymer Ltd. plant of Sarnia, Canada, included in some of these tables, is not a part of the United States Government program.

GOVERNMENT OWNED BUTADIENE PLANT OPERATED BY HUMBLE OIL, BAYTOWN, TEXAS

materials ranging from light gases to heavy hydrocarbons, are cooled and then fractionated to produce a narrow boiling fraction containing the butadiene. This is then treated for the recovery of the diolefin. Six plants have been scheduled for the Government program. The companies operating, their locations, and annual capacities in short tons are shown in Table 2.

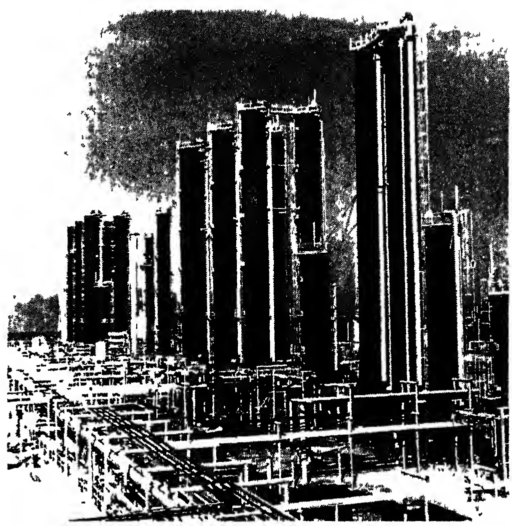
In addition to the Government plants, there are six butadiene plants that are privately owned and operated. These plants are all in operation and have a combined annual production of approximately 25,000 short tons of butadiene.

When all plants, both private and government owned, are operating at capacity, the total butadiene production of the United States and Canada will be in excess of 690,000 short tons per year.

In the absence of sufficient information, consideration of the relative merits of the processes based on petroleum raw materials and of those based on alcohol has led to heated discussions. At the present time both processes have operated long enough to clarify the matter. It appears that there will not be any very great difference in the capital investment per ton of capacity of the two types of plants, including the necessary auxiliaries for the production of the feed materials, and that the operating costs per pound of butadiene will be about the same for the various processes. It becomes, therefore, largely a matter of the relative cost of the raw materials employed and the value of the by-products produced. As indicated above, the petroleum processes will produce about 2.7 pounds of butadiene per gallon of butylene, or 2 pounds per gallon of butane, while a gallon of alcohol will produce from 2 to 2.5 pounds of butadiene. As far as initial feed stocks are concerned, it thus appears that the price of alcohol per gallon

should not greatly exceed the corresponding price of butane or butylene if the processes are to be competitive. Actually, the price of alcohol has been much higher than the cost of these hydrocarbons. On the other hand, the alcohol process produces certain valuable by-products, whereas the butane and butylene processes ha gas as a by-product. Even with the credit for these by-products, it does not appear that alcohol can be produced from grain, at the prices that have prevailed over the past five years, at a cost low enough to be really competitive with the petroleum butadiene operations. However, alcohol produced from molasses or synthetic alcohol produced from ethylene could probably compete with butane and butylene as a raw material for butadiene production.

Actually, it has been possible to construct the alcohol butadiene plants and to bring them into operation appreciably faster than the petroleum butadiene units. At the present time a high percentage of the butadiene is being produced by the alcohol operations, and it will be several months before the production of the petroleum plants exceeds that of the alcohol units.



FRACTIONATORS, BUTADIENE PLANT
OPERATED BY PHILLIPS PETROLEUM CO., BORGER, TEXAS

butylene to butadiene. In this case the crude mixture obtained by the dehydrogenation reaction is separated by fractional distillation, and the unreacted ethylbenzene is then recycled for further reaction. Six styrene plants were scheduled in the Govern-

TABLE 3. Plants Scheduled for the Production of Styrene

| *Operating company* | *Location* | *Annual capacity* |
|---|---|---|
| Monsanto Chemical Co. | Texas City, Tex. | 50,000 |
| Dow Chemical Co. | Los Angeles, Cal. | 25,000 |
| Carbide & Carbon Chemical Corp. | Institute, W. Va. | 25,000 |
| Polymer Ltd. (Dow) | Sarnia, Canada | 10,000 |
| Koppers-United Corp. | Kobuta, Pa. | 37,500 |
| Dow Chemical Co. | Velasco, Tex. | 50,000 |
| | | 197,500 |

Styrene constitutes the other main ingredient of GR-S. It is prepared by combining ethylene with benzene to form ethylbenzene. This operation is carried out at moderate temperatures in the presence of a catalyst. Most of the benzene employed is a by-product fraction obtained in the coking of coal, and the ethylene employed is produced either from ethyl alcohol or by cracking of petroleum products.

The ethylbenzene so obtained differs from styrene in the same way that butylene differs from butadiene; namely, it contains two more hydrogen atoms per molecule. Dehydrogenation of ethylbenzene to styrene is very similar to the dehydrogenation of ment program The companies operating, and the locations and short ton capacities of their plants are shown in Table 3.

All these plants are now in full or partial operation, and the processes appear to be satisfactory. In addition to the above Government owned plants, there is a private plant of the Dow Chemical Company at Midland, Michigan, which has been expanded during the present emergency. A large portion of the production of this private plant has been employed for the production of GR-S during the present year (1943).

*Polymerization.* Butadiene and styrene can be polymerized in various ratios and in a number of ways . The process selected for

the Government program involves the use of about 3.5 parts by weight of butadiene for each part of styrene. The actual polymerization is carried out by emulsifying the butadiene and styrene with an aqueous solution of the other chemical ingredients, and during the reaction period of between ten and twenty hours, about three-fourths of the butadiene and styrene are converted to the rubber-like material. In other words, the emulsified droplets of the liquified hydrocarbons are converted to small particles of solid rubber. When the reaction has proceeded to the desired degree, the unreacted butadiene and styrene are removed and recycled to succeeding batches. In this way a GR-S latex is obtained that is very similar in appearance to natural rubber latex. In other words, it is a milky suspension of the rubber particles. It can be used as a latex for certain dipping processes or it can be coagulated and the aqueous medium separated by filtration. After drying, the rubber crumbs can be baled or sheeted and then handled on the usual rubber fabricating facilities.

*Production of GR-S.* The Government program contemplates seventeen plants for the production of GR-S. The companies operating, and the locations and long ton capacities are shown in Table 4.

TABLE 4. PLANTS SCHEDULED FOR THE PRODUCTION OF GR-S (BUNA-S)

| *Operating company* | *Location* | *Annual capacity* |
|---|---|---|
| Firestone Tire & Rubber Co. | Akron, O. | 30,000 |
| Goodyear Tire & Rubber Co. | Akron, O | 30,000 |
| U. S. Rubber Co. | Naugatuck, Conn. | 30,000 |
| B. F. Goodrich Co. | Louisville, Ky. | 45,000 |
| U. S. Rubber Co. | Institute, W. Va. | 90,000 |
| Copolymer Corp. | Baton Rouge, La. | 30,000 |
| Goodyear Tire & Rubber Co. | Los Angeles, Cal. | 60,000 |
| B. F. Goodrich Co. | Louisville, Ky. | 15,000 |
| B. F. Goodrich Co. | Borger, Tex. | 45,000 |
| General Tire & Rubber Co. | Baytown, Tex. | 30,000 |
| B. F. Goodrich Co. | Port Neches, Tex. | 60,000 |
| National Synthetics | Louisville, Ky. | 30,000 |
| Polymer Corp., Ltd. | Sarnia, Canada | 30,000 |
| U. S. Rubber Co. | Los Angeles, Cal. | 30,000 |
| Firestone Tire & Rubber Co. | Port Neches, Tex. | 60,000 |
| Goodyear Tire & Rubber Co. | Houston, Tex. | 60,000 |
| Firestone Tire & Rubber Co. | Lake Charles, La. | 60,000 |
| | | 735,000 |

At the present time sixteen of these seventeen plants are in operation.

## PRODUCTION OF GR-I (BUTYL)

Butyl rubber is scheduled to be produced at the rate of 75,000 tons per year when the plants are in operation at rated capacities. Three plants included in the Government program (capacities in long tons) are listed in Table 5.

The Baton Rouge plant has begun operation and the two others are still under construction.

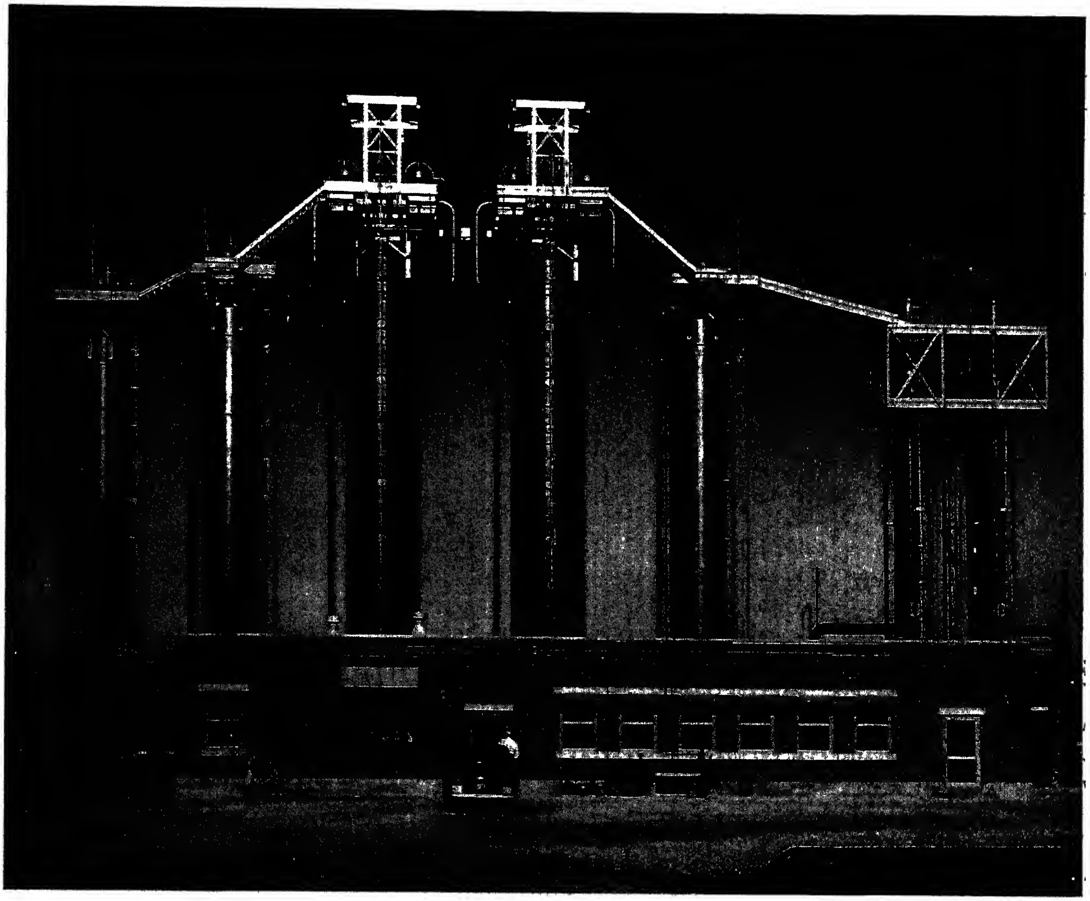
TABLE 5. PLANTS SCHEDULED FOR THE PRODUCTION OF GR-I (BUTYL RUBBER)

| *Operating company* | *Location* | *Annual capacity* |
|---|---|---|
| Standard Oil Co. of Louisiana | Baton Rouge, La. | 38,000 |
| Humble Oil & Refining Co. | Baytown, Tex. | 30,000 |
| Polymer Corp., Ltd. | Sarnia, Canada | 7,000 |
| | | 75,000 |

*Raw Materials.* Butyl rubber consists of from 96 percent to 99 percent isobutylene. Isobutylene is a low molecular weight hydrocarbon containing four carbon atoms to a molecule and having a single olefinic unsaturation. In the presence of the proper catalyst and under the proper conditions of temperature and pressure, it has the property of being polymerizable to an extremely high molecular weight, long chain compound. In doing so the olefinic bonds of the isobutylene molecules are used in joining other iso-

butylene molecules to form the chain. It results, therefore, in a material which is rubber-like but which does not contain the residual chemical unsaturation necessary for vulcanization. Isobutylene polymerized in this form is called Vistanex, or polyisobutylene, and has a considerable use as a rubber-like material. It is made vulcanizable by copolymerizing a small amount of diolefinic material, such as butadiene, isoprene or other diolefins, with the isobutylene. The addition of the diolefin leaves an unsaturation in the polymerized molecule that can be utilized for vulcanization. While other diolefins can be employed, the present GR-I program contemplates using a few percent of isoprene as the diolefinic material. Isobutylene is a by-product of the cracking of petroleum fractions, and it is concentrated by a series of extraction and fractionating steps to the high purity necessary for the butyl rubber reaction.

Isoprene is to be obtained from two sources: first, from thermal decomposition of turpentine and, second, as the by-product of butadiene production The second source is related to the thermal cracking of gasoline and heavier petroleum fractions for the production of butadiene. In this cracking process a by-product fraction of hydrocarbons containing five carbon atoms to the molecule is obtained. Isoprene is present in this fraction. By a series of fractionation steps, the isoprene is separated from the other hydrocarbons and concentrated to the desired purity.



STYRENE DISTILLATION COLUMNS, DOW CHEMICAL COMPANY, LOS ANGELES

The actual polymerization reaction is carried out by treating the mixture of isobutylene and isoprene with a catalyst at a low temperature. This results in a slurry of

small rubber particles in the reaction mixture. The resulting slurry is heated to flash off the unreacted constituents, which are reused, and the rubber particles are treated with hot water to destroy the catalyst. After screening to separate the water, the rubber particles are dried and then handled similarly to GR-S, or natural rubber.

### PRODUCTION OF GR-M (NEOPRENE)

The government program contemplates an eventual production of 40,000 long tons per year of GR-M (Neoprene GN). For this purpose a plant located at Louisville, Kentucky, is being constructed and operated for the Government by E. I. du Pont de Nemours and Company, Inc. The du Pont Company also has a privately owned neoprene plant with an annual capacity of approximately 9,000 tons. The entire Government plant is now in operation at rated capacity. GR-M is produced by the polymerization of chloroprene to give a long-chain rubber-like material.

*Preparation of Chloroprene.* Chloroprene is a substituted diolefin containing four carbon atoms to the molecule, the same as butadiene, in which one of the hydrogen atoms has been replaced by a chlorine atom. Coal and limestone are heated electrically to produce calcium carbide which is used to prepare the light hydrocarbon gas, acetylene. The acteylene is polymerized to give monovinyl acetylene which is then reacted with hydrochloric acid to give the desired chloroprene. Chloroprene is a light substituted hydrocarbon that easily polymerizes with itself to give high molecular weight rubber-like materials. Since it is diolefinic in character, the resulting molecule has a high degree of unsaturation.

The actual polymerization of chloroprene to GR-M is carried out in a manner closely analogous to that employed for the production of GR-S. Chloroprene is emulsified with water, and the polymerization reaction is carried out with the aid of a catalyst. This results in a latex containing small particles of GR-M, which can be used as such for dipping and coating or can be coagulated to give a massed form of the polymer. The vulcanization of GR-M is effected by heat without the aid of sulfur as a curing agent.

### PRODUCTION OF BUNA-N

Buna-N is a synthetic rubber produced in a manner very similar to the production of GR-S, with the exception that the reaction mixture contains butadiene and acrylonitrile instead of butadiene and styrene. It is not being produced in Government financed plants or as a Government sponsored operation. However, priorities on equipment for the preparation of the polymer and its raw materials have been expedited by the Government rubber agencies.

Acrylonitrile can be prepared in several ways, but it is chiefly made from ethylene oxide and hydrocyanic acid.

As already stated, the actual process for the production of Buna-N is almost identical with that used for GR-S and it is handled in much the same manner. An annual production of approximately 24,000 long tons of Buna-N type rubbers is contemplated.

## III

### COMPARISON OF PROPERTIES OF THE VARIOUS SYNTHETIC RUBBERS

GR-S is a general purpose type of synthetic rubber that processes and vulcanizes in a manner similar to natural rubber. In general, it has desirable physical properties, although in a few important characteristics it is definitely inferior to natural rubber for some uses. In other uses it is the equal, if not the superior, of natural rubber. It should be possible to use GR-S for most of the important uses of natural rubber. For example, it is believed that it will be possible to produce automobile tires that are about as satisfactory as the tires made from natural rubber. An intensive research and development program being carried on by a number of the rubber, petroleum, and chemical companies, and by educational institutions in cooperation with the Government, is continually developing improvements in the GR-S type of rubber. In fact, recent developments give promise of overcoming the most serious drawbacks of GR-S. In general, its processing characteristics are very similar to those of natural rubber. It appears very likely that within a few years this general type of rubber will be essentially the equivalent of natural rubber for most uses.

GR-I, owing to its different chemical char-

acter, has properties somewhat different from those of natural rubber and GR-S. While it may develop into a general purpose rubber, the main immediate uses will be those based on its special properties, such as its impermeability to gases and vapors, and its excellent age resistance. Thus, GR-I inner tubes hold air better than those made of natural rubber. It likewise should be useful for coating fabrics where impermeability to gases is important.

GR-M is a synthetic rubber that was employed on an appreciable scale prior to the present emergency, since it possesses special solvent resistant properties that are not obtainable with natural rubber. While the cost of neoprene was several times that of natural rubber, these special properties made it economically competitive. Neoprene also has excellent aging properties, particularly resistance to sunlight, and it is, therefore, valuable in covering fabrics that will be exposed, such as balloon fabrics. The GR-M produced in Government plants will be used largely for purposes for which its special properties make it valuable, although the quantity contemplated may be large enough to make some available for general purposes. It is satisfactory for general uses with the exception that it becomes brittle at the low temperatures that are likely to be encountered in high latitudes. The low temperature properties can be improved by the preparation of special copolymers of chloroprene, but the production of these copolymers is not now contemplated in Government owned plants.

Buna-N, which was produced on an appreciable scale before the present emergency, is also employed as a special purpose rubber. It has exceptional solvent resistant properties, particularly for liquids such as aromatic hydrocarbons. Essentially all the Buna-N is now employed in uses that are based on its solvent resistance. It could be used as a general purpose rubber, but its properties are not enough different from those of GR-S to justify its much more difficult processing and its much higher cost.

At the present time synthetic rubbers of the four types that have been discussed are being produced at an annual rate in excess of 500,000 long tons. Over the period of the next few months this production rate will be stepped up to the order of 600,000 to 700,000 long tons per year, and then sufficient synthetic rubber should be available for all essential uses.

The future of synthetic rubber is a question that is always raised when rubber production is under discussion. The problem is very involved and obviously will not be completely answered on purely technical and economical grounds. It is also undetermined whether the plants will continue under government ægis after the emergency or will be turned over to private ownership.

There is no question that special rubbers of the type of Buna-N and GR-M will be produced on an appreciable scale regardless of the cost or availability of natural rubber, because they are desirable for a number of uses for which the natural material is not satisfactory.

The case for GR-S and GR-I is not as clear as that for Buna-N because they will be more nearly in direct competition with natural rubber. It is believed that they can be produced for a price of fifteen to twenty cents per pound, including a reasonable amortization and return on the investment, and there is a possibility that they can be developed at a cost less than fifteen cents per pound. This price range compares favorably with the average price of natural rubbers over the past decade, but if the prevailing economic conditions in the rubber producing countries should be the same after the war as they were prior to it, there is no question that natural rubber can be delivered to the United States at a cost less than fifteen cents per pound and still show a satisfactory return for the plantations.

It appears likely that both natural and synthetic rubber will be used in the future. The availability of the synthetic rubber will stabilize the price structure and prevent the large fluctuations in prices of rubber that have prevailed in the past. It will also be very much to the national interest to maintain a synthetic rubber production large enough to meet the initial impacts of future emergencies. The continued use of synthetics over a period of years will also develop the necessary technical knowledge relative to their production and uses and will, therefore, obviate the intense research, development, manufacture, and testing that are necessary at the present time.

# THE AMAZON—HAS IT BEEN FULLY DISCOVERED?

By ALBERT F. KUNZE

In the year 1502, more than a century before the Pilgrims landed on Plymouth Rock, while Henry VII, first son of The House of Tudor, ruled over Britain, the existence of the great Amazon was discovered. That was more than four centuries ago.

Today the potentialities of the Amazon River and its incomparable basin of some 2,722,000 square miles—over twice the estimated drainage area of the Mississippi and its combined tributaries—is still a vast region of undiscovered treasure. As the years progress chemistry will find uses for the myriad of plant species indigenous to the Amazonian basin; engineers will harness the untold horsepowers of energy that have, for centuries, wasted themselves in their journeys through the virgin jungles to the sea; botanists, biologists, and ornithologists will enrich their sciences with discoveries in regard to the flora and the fauna of the Amazonian tropics; and among other phenomena to be studied archeologists may analyze the earthly lamina of this "great unknown" to solve mysteries predating those of the Pre-Columbian era. In the fields of science the Amazon River is still a vast virgin world in itself, awaiting exploration and exploitation in the light of modern advancements.

Its long arms of flowing waters, capable of moving ocean craft for more than 2,000 miles westward from the Atlantic Ocean, beckon to the engineers of navigation, inviting them to utilize its watery pathway to bring to manufacturing and commercial centers, natural wealth that is so profusely to be found in but few places on the face of the earth.

The "dreamers" of the lands through which these waters flow have perhaps not failed to appreciate the potentialities of the natural assets that lie there unused. Three governments have, through the same medium, seen fit to invite attention to this watery Colossus of the Western Hemisphere. Their chosen vehicle of publicity has been drama in a picture form with which all

FIG. 1. (A) FRANCISCO DE ORELLANA (B) FRANCISCO PIZARRO

FIG. 2. (A) OLD MAP OF SOUTH AMERICA (B) ORELLANA AND HIS CREW

residents of their great areas are in intimate contact—postage stamps. Used by all who read, they convey their silent messages to the far corners of the world.

While it is true that none of the group of twenty-one stamps dedicated to the Amazon openly touches on the future development of this river, it is not at all improbable that this subject may have been in the minds of those who promoted their issuance.

In this era of experimentation many novel ideas have been tried. The direction and guidance of public thought is one development of political science that has received much attention. In the stimulation of national ideologies, postage stamps have played an important and surprisingly large part. World's Fairs, religious observances, and national industrial opportunities have frequently been depicted on postage stamps. On innumerable occasions political philosophies have been epitomized in the portraits of such heroes as Bolivar, San Martín, Washington, Artigas, and Sucre.

During the years 1940, 1941, and 1942 Ecuador, Peru, and Brazil dramatically invited attention to the mighty Amazon through postage stamps. In all three cases the four hundredth anniversary of the discoveries of Gonzalo Pizarro and Francisco de Orellana have been used as justification for these postal issues. Their adventures constitute a series of the most dramatic incidents in all of the sensational history of the unfolding of the Western world (Figs. 2A, 3).

In 1540 a substantial Spanish population had already gathered in widely separated localities of South America. The settlers, largely conquistadores and adventurers, had a fair conception of the general geographical characteristics of the land to which the lure of wealth had drawn them. Their ancient maps, as shown on the 40c. black and yellow air mail stamp of Ecuador, illustrate their fairly accurate concept of the vast South American continent.

Prior to that time, in the year 1500, Vincente Pinzon, one of the Captains of the original Columbus expedition, skirted the eastern shore of this great "island," as he presumed it to be. At a point close to the equator he fell upon a mystery more baffling than any he had previously encountered. The salty nature of the ocean had changed to fresh water. The aimless tossings of its billows assumed a slight current, directed toward no particular destination but emanating endlessly from between two points of land so widely separated that to his mind they could not have been the opposite shores of a river. As Pinzon sailed his ship westward between them he became more perplexed than ever, for nowhere in the experiences of Columbus, The Great Navigator, or the scientific discourses of Toscanelli, or the fantastic writings of Marco Polo, had the story ever been told of a body of fresh water

lying within or adjoining the great salty ocean. After sailing westward for several days against the increasing current, he christened the strange waters with the name "Mar Dulce" and contented himself with having it noted in his log, leaving the significance of the strange experience to others.

So incomprehensible was the enigma Pinzon had presented that the "wise men" of the old world demonstrated their wisdom by remaining silent. As a result four decades and longer passed before the world realized that Vincente Pinzon had, in fact, achieved one of the greatest discoveries of the New World. Pinzon and a whole generation of his fellow men died without ever having realized that he had discovered the giant of New World waterways, later named the Amazon.

To this day, and perhaps for all future time, however, the discovery of the Amazon will continue to be accredited to another conquistador. This capricious award of fame is no doubt attributable to the more sensational and melodramatic story of Francisco de Orellana and the manner in which he became associated with the Amazon. In truth, it might be recorded that, while Vincente Pinzon discovered the existence of the river, it remained for Orellana to discover its greatness and, vaguely, its course. Strangely, they approached the river from opposite ends, Pinzon unknowingly having entered its mouth and Orellana having traced its course down the eastern slope of the Andes, beginning 3,000 miles from its mouth in the highlands of the Republic now known as Ecuador.


FIG. 3. ANCIENT MAP
SHOWS EXAGGERATED IDEA OF THE AMAZON'S BREADTH.

The early seat of Spanish authority and military power centered about the Vice-Royalty of Peru where Francisco Pizarro, the Viceroy, ruled with uncompromising authority. His fame and success was to no small extent due to the loyal prowess of his brother Gonzalo, and to his lieutenants, Francisco de Orellana and Diego de Almagro (Fig. 4A). As the dominant Pizarro's prestige rose, so Almagro's ambition for recognition and reward increased, and as has so often been the case where friends of unusual prowess vie, disagreement soon arose. The Viceroy Pizarro knew but one satisfactory course to pursue when his power was challenged.

In 1538 he dispatched a substantial force of his military strength under command of his brothers Gonzalo and Hernando against Almagro, and assigned an important military task to his trusted friend, Francisco de Orellana. Their forces were large and their equipment surpassed that of Almagro who suffered defeat, and, after surrendering, the penalty of death for his insubordinate challenge to the authority of the Viceroy Francisco Pizarro. Gonzalo Pizarro was rewarded for his successes by being named Governor of the Province of Quito (Fig. 5B).

The military skill and the daring of Orellana in warfare so pleased the Pizarro brothers that the intrepid soldier received high praise and was rewarded with the title of Governor's Lieutenant General of the newly founded city of Santiago de Guayaquil, situated high among the peaks of the Andes. There he demonstrated that he was as proficient in civic administration as he had been successful in battle. Guayaquil, as a vassal city to that of the Viceroy, prospered and grew (Fig. 5A).

The early Spanish conquistadores, however, were not an agricultural people content


FIG. 4. (A) PIZARRO AND ORELLANA (B) ORELLANA, DISCOVERER OF AMAZON

to establish a community and live on such products of the land as its resources might offer. Gonzalo Pizarro well recognized that fact and found little difficulty in convincing his brother, the Viceroy, that it would be well to organize a strong force to move eastward to discover and take possession of the fabulous wealth of El Dorado, the Man of Gold, and of La Canella, the Land of Cinnamon. No difficulty was encountered in recruiting a following to proceed on an adventure that promised such rich reward. According to Indian report and tradition, El Dorado possessed wealth in gold that knew no bounds. The most menial utilities were made of the precious metal that glittered and scintillated in the brillance of the ever present tropical sun. It came from sources that were seemingly inexhaustible. El Dorado alone knew of their locations. Then too, in the same general direction as the abode of El Dorado, was the Land of La Canella where the fragrance of cinnamon perfumed the air with a deep, piquant, stimulating odor that surpassed the exotic and aromatic incenses of Oriental spice lands.

Toward the attainment of these rewards awaiting mere taking by the Spaniards, the adventurers rallied to the call of Gonzalo Pizarro. Several thousands, including Indian servants, made ready to follow the leaders appointed by the Governor, chief among them being Francisco de Orellana and Gonzalo Diaz de Pineda. With munitions of warfare, building materials, food supplies in casks and bales, and even livestock on the hoof, they finally got under way. Late in February of 1541 the advance unit of the expedition set forth (Fig. 6).

By day they traveled down paths of verdant grasses and at eventide paused in a cool ravine to enjoy relaxation and a satisfying meal. They gathered before open fires to revel in the interpreted stories of their native Indian guides. Each evening the Spanish adventurers relaxed to absorb further and more exaggerated stories of the glittering golden horde of El Dorado. As succeeding nightly camp fires were lighted, the men were assured that the land of their desire was but a few days further travel toward the rising sun. Each morning they arose at dawn fired with the certainty that the forthcoming day's journey would bring them closer to El Dorado. In their enthusiasm less consideration was given to the fact that


FIG. 5. (A) SANTIAGO DE GUAYAQUIL (B) QUITO, CAPITAL OF PIZARRO'S PROVINCE

food supplies were diminishing than to the hope of reaching their desired destination of gold They appeared wholly oblivious to the fact that the dense vegetation through which they were forging their way offered no fresh supplies of food and that animal life consisted largely of snakes, lizards and ugly monsters that crawled on their bellies.

One day, however, the situation in regard to their lack of food stores dawned on them with startling emphasis. They held a consultation and it was decided that a brigantine was to be built which, freighted with their heavier burdens of munitions and cannon, was to move down the river to a point where, it was told, supplies of fresh meats and vegetables were to be found. There the heavier articles of their equipage were to be left, along with some of the men. Food was to be brought back on the return trip and then all were to proceed onward again to the Golden Land of El Dorado.

The plan was excellent. While the brigantine was being constructed of rough hewn forest logs, further consultations were held as to which of the Governor's lieutenants was to captain the ship. Gonzalo Diaz de Pineda was the only one seriously considered beside Francisco de Orellana. A decision was quickly reached, the former being assigned to remain with Gonzalo Pizarro and the main contingent of the soldiers, while Orellana accepted the honor and the responsibility of leading the contingent about to go forward for food.

In ambitiously accepting that assignment Orellana unknowingly was facing the turning point of his life. As a result of this new phase of his adventure, the high regard of the Pizarros, both Viceroy and Governor, was to turn from admiration to vindictive hatred, and the former praise he had received as soldier and as chief of the City of Santiago de Guayaquil was to be succeeded with charges of insubordination, treason, and treachery. As a matter of actuality his reputation became sullied with the most unkind and uncomplimentary aspersions which endured for centuries after he had died.

Orellana, born in 1511 in the town of Trujillo, Province of Esremadur in Spain, was the son of a prominent family. He was hardly more than a boy when he went to sea. In the service of Francisco Pizarro, to whom he was distantly related, he found a place among the early conquistadores who introduced the blood of Spain into the New World. During early life, in one of many hand-to-hand battles he lost one of his eyes, which added color to the infamous title, "the One-Eyed Traitor," by which he was long known in the records of history—accepted as authentic until the end of the nineteenth century.

In 1894 Jose T. Medina, a deep student of the source materials of writings long accepted as authoritative, completed a research that had engaged his major attention for a long period of years. He had taken issue with the record "created" by Jiménez de la Espada some three hundred years before, while lingering reflections of the old Pizarro-Orellana feud still persisted. Medina's views now appear not only to warrant favor, but to possess a logical sequence of factual data that

justifies the honor and prestige restored and rightfully belonging to Francisco de Orellana (Fig. 4B).

On December 26, 1541, amid salvos of good wishes and the cheers of his comrades, Orellana captained the brigantine his fellow adventurers had built and started eastward on what was to have been a mission of mercy in finding food and returning it to his companions. He planned to move downstream with the aid of his sails and the mild current, and then to return. The stream broadened as he proceeded, the waters took on a more powerful movement, and the jungle land became more dense, but neither villages nor edible vegetation greeted the ever watchful eyes of Orellana and his men.

From time to time occasional small bands of jungle natives greeted him through unfamiliar signs and incomprehensible mouthings. Through them Orellana was led to believe, or chose so to interpret their messages, that supplies of food were to be found ahead after another day of travel. But as each day waxed from noon to night, the quest lured him further down stream. The current increased, the river widened, and the waters,

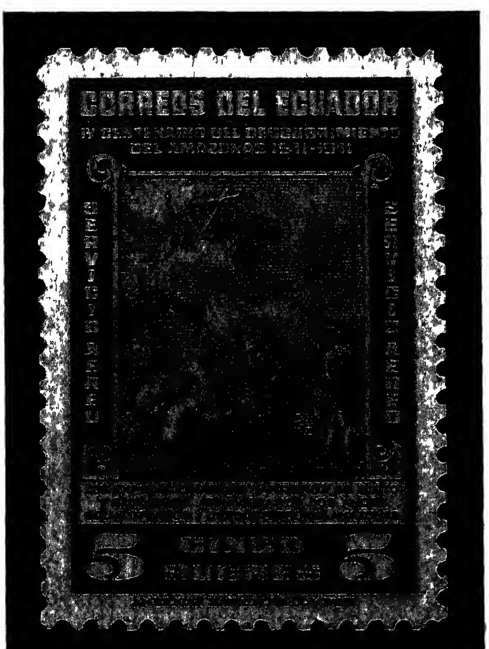



FIG. 6. ALLEGORY OF EXPEDITION WHICH ENDED IN THE DISCOVERY OF THE AMAZON


FIG. 7. THE AMAZON RIVER
ANCIENT MAP OF THE RIVER AND ITS AFFLUENTS

fraught with cataracts and rapids, rendered progress more dangerous with every hour. Each day his surroundings changed—even the character of the natives differed. In place of friendly Indians he met with a savage tribe whose greetings were conveyed by arrows with hardened tips bathed in the poisons of the jungle. They were an odd lot; according to the record of the historian Carvajal, they had fair skins, long blonde hair, and wore tunics that reached to their knees. As a result of this record, however clothed with imagination it may have been, these unfriendly natives were referred to as the feminine Amazon warriors of the New World. Battle with them and even flight from their missiles called for all the skill Orellana could command (Fig. 2B).

Orellana's food stocks ebbed and then disappeared entirely. The captain of the mission of mercy in search of food for his companions upstream began to realize that his temporary assignment had, for the time being, assumed less importance than his own growing predicament of danger. The increasing river current, the savage natives, and his crew of men whose morale had

reached its lowest ebb with cases of scurvy and other diseases prevalent, constituted problems that had changed the whole world for Orellana. In heart and mind he had not forgotten Gonzalo Pizarro and the mission he had been called on to perform, but as a practical matter there was no course for him to pursue other than onward into the indefinite spaces ahead at the mercy of the current and the winds. Had it been possible for Orellana to return to Pizarro, it was obvious that there was no point in taking that chance for the single purpose of reporting a failure to accomplish his objective.

Onward with the current Orellana willingly or otherwise plunged, finding the task of keeping the keel of his ship beneath him as much as he could manage. Torrential rains further handicapped his better management of the brigantine, the rains beating upon its deck with such force that the forecastle was not visible from the stern of the ship. Days followed weeks with a monotony varied only in the type and character of changing dangers. Time had lost its significance, direction had no meaning, even a destination was of less interest to Orellana than the ever present consequences of hunger. Starvation, scurvy, and death all took their toll as the nameless brigantine tossed and lurched its way down stream to an unknown destination.

St. Louis Day late in August of 1542 dawned and unexpectedly proved to be the end of a voyage auspiciously begun eighteen months before—a voyage that was intended to have lasted but two weeks. Orellana and his men had reached the Great Ocean, having traveled some three thousand miles eastward from the Andes. The original objective of their mission had long since been forgotten yet it was, according to Medina, "in this way that they brought to an end their navigation and experience which had been entered upon unintentionally and turned out to be so extraordinary that it is one of the greatest things that ever happened to men."

Orellana's original objectives of finding El Dorado and La Canella were never realized. His secondary mission of obtaining food for his companions was likewise never accomplished. For this latter failure he was censured throughout the realm of the Pizarros as having been a traitor in deserting his companions in the hour of their greatest need. In Spain, after the full extent of Orellana's journeys became known, he was acclaimed a hero on whom great honors were bestowed. But his triumph was transitory. At the height of his fame he was sent to Colombia to investigate a difficulty which had arisen between certain of the Spanish officials stationed there. After familiarizing himself with the situation he made the unfortunate error of ordering the arrest and imprisonment of several members of the "Audencia." The Council of the Indies in Spain, on reviewing the situation, disapproved of Orellana's action, and in turn, ordered him to prison where he died a short time later. So destitute was the great voyager, that it became necessary for someone else to meet the expenses of his funeral.

Despite the misfortunes of his own life, Orellana is today credited with the distinction of having been the first man to have navigated the entire length of the Amazon, thus bringing recognition of its immensity to the world (Fig. 7). His reports stimulated a series of exploratory voyages to and up the river and its several tributaries. Among them the most dramatic were those of Lope de Aguirre and, later, that of Pedro de Teixeira. Despite these explorations, the Spaniards acquired only a vague idea of the magnitude of the Amazon, its tributaries and drainage basin. This is evidenced by their crude maps, now obsolete, several of which are to be seen on the recent postage stamps of Ecuador and Peru. A fuller picture of the vast reaches of the Amazon, at least insofar as the Brazilian basin is concerned, is to be noted on a 1943 brown map stamp of Brazil released by Brazil in 1943.

The increased needs of world markets for many basic materials and substitutes for others, so sternly realized in connection with the prosecution of World War II, has brought a distinct change to the Amazon Basin. The great rubber industry has reawakened, embracing not alone the agricultural phases of cultivation but likewise the subject of manpower coupled with the endless human needs of food, shelter, and clothing for the workers and their families,

schools for their children, health and sanitation facilities, and the equally great problem of transportation by land, sea, and air. Rubber is said to have been indigenous to the Amazon valley, although later cultivated in the East Indies and Africa where it gained great commercial prosperity. From present indications it would appear that the Era of Rubber in the Amazon Valley is about to begin.

Quinine, a product of the bark of various species of the cinchona tree, is likewise a native of the Ecuadorean and Peruvian basins of the Amazon. The unprecedented movement of men to tropical climates in connection with the pursuit of World War II, so stimulated the need for the medicinal powers of quinine that the cultivation and treatment of cinchona trees of the Amazon valley have received an impulse greater than ever before. Woods of a wide variety, fibers, tin, manganese, and other natural resources in quantities and grades still unknown lie dormant in the huge Amazon Basin covering an area larger than that portion of the United States east of the Mississippi River. Many species of native flora of the Amazonian regions still remain subjects of chemical and commercial experimentation and exploitation such as the vegetable ivory trees, the babassú nuts and the carnauba palm. This latter species, which flourishes in the dry regions of the northeast has already received considerable attention. In regard to it Professor Fred A. Carlson of the Ohio State University has written in his *Geography of Latin America:*

> The root is depurative and is widely used in treatment of blood diseases. From the bark is prepared a meal which is highly prized. The trunk furnishes a wood employed in rough timbering. The fruit is an excellent food for animals, and when ripe, has a soft, dark, lustrous sweet pulp which is delicious either raw or made into a conserve. Around the fruit is a shell five inches in diameter, which when roasted, is made into a drink resembling coffee, and which yields an illuminating oil. From the surface of the young leaves comes the famous carnauba wax which is widely used in phonograph disks, in cinema films, in insulation for cables and in candles.

To science the great Amazon River and its far-reaching Basin still remain to be discovered with a view to a fuller use of their abundant natural wealth. As Vicente Pinzon in 1500 discovered the existence of the river, and Orellana in 1542 its length and course, so, even today, after a span of more than four centuries, there remains for discovery through the advanced sciences of our generation, a multitude of practical uses for the natural assets of the Amazon Basin.

*Vatican*

MYTHOLOGICAL AMAZON
FIFTH CENTURY, B.C.

# AGAR: A VALUABLE SEAWEED PRODUCT

By C. K. TSENG

THE importance of agar[1] in culture media for bacteriological and other microbiological research is well known in the scientific world. The United States, like other countries, used to depend principally on Japan for her agar supplies. Under the present conditions this source of agar is no longer available. The resulting agar shortage has become the concern of the Government. Consequently much attention has been given to problems regarding agar by various scientists—bacteriologists, botanists and chemists. There are already several articles recently published in *Science* and elsewhere, on methods for reclaiming used agar, on new sources of agar, and on the preparation of agar substitutes.

### AGAR: HISTORY AND NOMENCLATURE

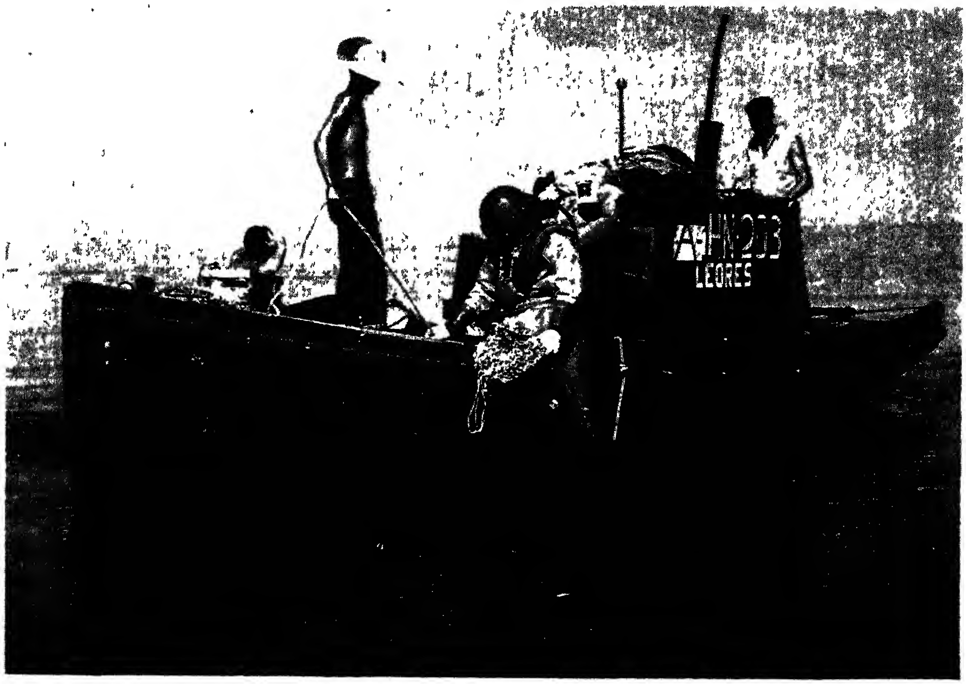
In undertaking certain research problems with regard to the agar resources on the Pacific coast, the writer found a great deal of confusion existing in the use of the term agar. There is also misinformation about the sources of agar. The confusion is mostly due to the fact that the word "agar" or "agar-agar" was originally the Malay name for certain East Indian red algae, but is now almost exclusively used in science to designate the dried gelatinous extract derived from other seaweeds and produced principally in Japan. Thus, contemporary scientists writing on agar as we understand it nowadays not infrequently quote facts concerning *agar* as the word was used originally. Therefore, in order to avoid further confusion in this matter, it is necessary to standardize the application of the word "agar," restricting its use only to the dried extract. For the sake of simplicity the word "agarphyte" is here suggested to apply to the seaweeds used in its manufacture, instead of the more elaborate combinations of words such as "agar-bearing seaweeds," "agar-producing seaweeds," and "agariferous seaweeds."

*The Original Agar.* The original Malay word, *agar* or *agar-agar*, applies to certain common edible red algae, especially *Eucheuma muricatum* f. *depauperata* (= *Eucheuma spinosum*) of the Dutch East Indies, but is used indiscriminately for other species of the same genus. *Eucheuma muricatum* has been exported as *agar-agar* from the Dutch Indies to China for more than a century. It is quite common on Chinese markets, known under the popular name *Chilin-ts'ai*, meaning "Unicorn Vegetable." Quite erroneously, most authors have assigned the name "agar-agar" principally to *Gracilaria lichenoides*, which, to the knowledge of the writer, has never been used in China for making agar or in Ceylon where agar has never been made.

*Introduction of Agar into Bacteriology.* The introduction of agar into bacteriology has been discussed in detail by Hitchens and Leikinde. These authors credit the discovery of agar as a medium for bacteriological culture to a housewife, Frau Franny Eilshemius Hesse, who suggested to her husband, a bacteriologist, the use of agar-agar "which she had been using for years in her kitchen in the preparation of fruit and vegetable jellies." This discovery was communicated by Dr. Hesse to Robert Koch, "probably late in 1881." Because agar gel is relatively inert, is not liquefied by most bacteria, and remains in firm consistency at the incubation temperatures for the growth of various types of bacteria, it has helped greatly to advance the science of bacteriology.

It is, of course, impossible now to determine what was actually the "agar-agar" which Frau Hesse and eventually Koch used in this important discovery. Hitchens and Leikinde make this remark: "While yet in America she had received the recipe from her mother; her mother in turn had obtained the formula from some Dutch friends who

[1] "Agar" is preferred to "agar-agar" for the sake of simplicity. The word is pronounced in Malay with both *a*'s as in "arm." To follow the native Malayan tongue strictly the *r* should be pronounced like that in German. In this paper, whenever the word *agar* refers to the original Malay meaning, it is italicized.




DIVER DESCENDING WITH BASKET TO HARVEST AGARPHYTES*

had formerly lived in Java." From this note it may be reasonably inferred that the material used was the true East Indian *agar-agar*—the seaweed *Eucheuma muricatum,* rather than the dried extract from Japan.

The writer has as yet no definite information as to when the Japanese preparation was exported to Europe in quantities, and when it began to be called by the Malay term. From evidences in the writings of botanists and chemists in the 19th century, it seems that the Japanese product was already known by the European scientists in the 1860's, that it was then a very rare article—probably not something which the housewives could use in their kitchens—and that it still had no connection with the word agar, which was invariably used to designate certain East Indian algae, especially *Eucheuma spinosum.* As late as 1893 the Japanese government in the World's Columbian Exposition still called this *Gelidium* extract merely "dried seaweed jelly," instead of agar-agar as might be expected if it were already known by that name and exported as such in quantities to the Occidental countries.

*Modern Use of the Word Agar.* At the beginning of the present century the Japanese scientists, such as Yendo, had already called this peculiar Japanese product "agar-agar." Somehow, because of the persistence of the bacteriologists, the scientific world has generally accepted as agar, without further questioning into its origin, the dried gelatinous *Gelidium* extract in the form of powders, flakes, strips, or blocks from Japan, rather than the seaweed *Eucheuma* itself, the true *agar-agar.* Using the term as it is now generally accepted by scientific workers and dealers, we must give the seaweeds from which this peculiar extract is commercially prepared a separate name—"agarphyte" as proposed here—in order to avoid further confusion in the matter of terminology.

*Definition of agar.* It is to be noted that the definitions of agar that have appeared in various contemporary standard works are partly incorrect and as a rule too vague, because they apply not only to agar but also to other red seaweed extracts, such as carrageenin from Irish moss. Although our present knowledge of agar is still too incomplete to warrant a definition that would be acceptable to all scientists, it is advisable that

* All photographs courtesy U. S. Fish and Wildlife Service.

a revised definition be available. Such a definition should be broad enough to include products most scientists would agree to call agar, but precise enough to differentiate it from closely related but definitely different products, such as carrageenin mentioned above. Therefore, the writer ventures to offer the following definition for agar: The dried amorphous, gelatin-like, non-nitrogenous extract from *Gelidium* and other red algae, being the sulfuric acid ester of a linear galactan, insoluble in cold but soluble in hot water, a dilute neutral solution (1 to 2 percent) of which sets, upon cooling, to a firm gel solidifying at 35° to 50° C., and melting at 90° to 100° C

### Agar Production and Consumption

There has been a good deal of misinformation in the literature about the sources of agar. For instance, Tressler writes in 1923: "Most of the agar of commerce comes from Japan, China, Malaysia, Ceylon and neighboring coasts." At that time none of these countries except Japan, of course, produced any commercial agar. One botanist makes the following remark in a publication in 1917: "In the past agar-agar has been made principally in Germany from algae obtained from Japan." To the writer's knowledge Germany has never produced any agar so far, although she has made a purified agar from the Japanese product. Such misleading notes have been quoted again and again in current literature.

Japan is most probably the first country to produce agar in its present form. There are several theories as to when the present method of agar manufacture involving freezing and thawing was discovered, and according to Horiuchi, the following four years have been suggested: 1647, 1655, 1658 and 1688. Recently Chase reported, "The Chinese introduced it to Japan in A.D. 1662." In a recent communication she wrote the writer that her information was based on an old Japanese encyclopedia. The confirmation of any of these theories will be of some historical interest.

Japan is, and probably will always be, the leading agar producing country, in view of the vast quantity of agarphytes produced on her extensive coast, her well established agar industry, her low cost of production, and the appreciation of agar as food by her people. Agar is produced principally in the Osaka, Hyogo, Kyoto, Nagano, Yamanashi and Gifu prefectures where the climate is favorable for its manufacture by the old method. Some agar is also produced in Karafuto (Saghalien) where it is extracted from a different material by a different method. According to Horiuchi in 1936, there were 512 establishments with a total output of 679,918 kans or 5,622,921 lbs., worth 9,712,497 yen, or about $2,400,000. The total export that year was 3,921,638 lbs., worth 5,574,452 yen, or about $1,400,000.

Up to the outbreak of war in 1937, China had a small agar industry consisting of three factories located at Ningpo, Tsingtao and Chefoo. No published data were available as to their total annual output. On the basis of information obtained from two of the firms and of the amount of agarphytes produced in China, the writer estimates the Chinese annual production at about 75,000 lbs., which normally was worth about 200,000 yuan, or approximately $50,000.

The United States has been making agar for about 28 years. The annual production has been very irregular, varying from 1,802 lbs. (1934) to 44,895 lbs. (1930), and in one exceptional year (1925) was as much as 117,773 lbs. Until 1941, when the domestic production was about 52,000 lbs., only one factory was actively engaged in making agar. The war has greatly stimulated the growth of this industry and now there are five concerns devoted to agar production, all located in southern California. The expected annual output will total 200,000 to 250,000 lbs.

In recent years Russia has also paid much attention to the production of agar from local seaweeds. According to Kizevetter, Vladivostok and Archangel each produced 44,000 lbs. and Vladimir 33,000 lbs., making a total output of 121,000 lbs in 1936. Besides, Odessa in the Black Sea was reported to have produced 440,000 lbs. of "agaroid" in the same period. This substance is probably of the nature of a seaweed gum similar to carrageenin. If, however, it proves to be a true agar as defined above, the Russian production in 1936 would have far exceeded

that of the United States even at the present rate of production.

The agar industry in the Netherlands Indies is a recent one. There were reported to be two factories in 1938. The total output was not known. At present both Australia and New Zealand are very actively investigating their agar resources. Recently Wood reports that an Australian firm is producing its own requirements for meat canning and that others will be making "agar" soon. This "agar" is undoubtedly in the form of a gel which is directly used in canning without passing through the freezing-thawing-drying processes, as the same author remarks, "no dried agar has yet been produced." Information reaching the writer reveals that South Africa has a rich natural resource of *Gelidium* and other agarphytes, still untapped, and enough to develop a great agar industry. A firm at Capetown was reported to have produced some agar-gel which was used directly in making confectionery. Perhaps these countries are producing some true agar by now. In Baja California, Mexico, from which came the majority of the *Gelidium* used in the United States in 1942, a small factory with a capacity of a ton of dry *Gelidium* per month is already in operation, and a larger one is being built.

On the basis of these data and information the writer estimates the world production of agar at six million pounds per annum of which 90 to 95 percent is made in Japan.

Japan also leads the world in the consumption of agar. According to Horiuchi, out of the total production of 2,207,378 lbs. in 1902, 366,542 lbs., or 16.6 percent, were consumed in that country. In 1936, while the production increased 2.6 times to 5,622,921 lbs., the consumption increased even more significantly by 5.7 times to 2,112,736 lbs., constituting 37.6 percent of the total production and about 0.35 ounces per capita. Agar consumption in China used to be over a million pounds per annum up to the early part of this century. Of the total Japanese export of 1,767,528 lbs. in 1906, 1,284,633 lbs., or about 73 percent, went to China and Hong Kong. In recent years, because of the enormous increase of price of agar, because of some local production, and because of the strained relation between China and Japan,

HAULING IN A BASKETFUL OF *GELIDIUM* WEIGHING ABOUT 65 POUNDS

the Japanese agar export to China has declined drastically. In 1938 China, including Hong Kong, imported only 109,592 lbs. Normally China would consume at least six to eight hundred thousand pounds annually for food alone.

The United States imports of Japanese agar during the last few years before the outbreak of war fluctuated between 500,000 and 700,000 lbs. In 1941, besides making 52,000 lbs., she imported 565,059 lbs. from Japan and 32,413 lbs. from China. According to Kizevetter, Russian consumption is about 660,000 lbs. per annum. In 1938 Germany imported 596,239 lbs., France 442,225 lbs., England 294,329 lbs., Dutch East Indies 162,393 lbs., Australia 144,571 lbs. and Strait Settlements 58,520 lbs., all from Japan These imports represented, presumably, also the amounts consumed by these countries. It is to be noted, however, that the Dutch East Indies and the Strait Settlements have long been using a large quantity of local seaweeds to prepare their own agar gel.

THE AUTHOR GOES UNDER

DIVING TO STUDY GROWTH RATE AND QUANTITATIVE PRODUCTION OF *Gelidium* ON CALIFORNIA COAST.

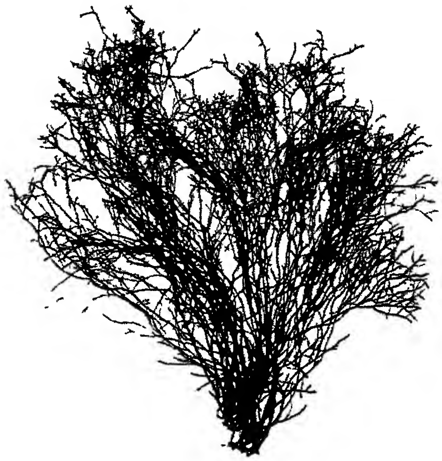
USES OF AGAR IN MEDICINE AND SCIENCE

Agar originally was used in making jelly and certain food preparations in the Orient. Since 1882, when it was first introduced into bacteriology, its technical uses have increased enormously.

*As Microbiological Culture Medium.* This is the most important use of agar, so far as human welfare is concerned, although the quantity of agar actually employed in this way constitutes only a minor portion of the total. Undoubtedly agar has received more respect and honor in this service than in all the others put together. Its chief value as a culture medium lies in the firm consistency of its gel at incubation temperatures for the growth of bacteria and other micro-organisms, and in its inertness towards most bacteria. These were the two main reasons which motivated bacteriologists in the latter part of the last century to prefer agar to gelatin as a culture medium. Agar is also remarkable for melting at about 95° C. and solidifying at about 40° C. Because it remains liquid when cooled to 42° C., organisms may be thoroughly mixed with it at a temperature that does not injure them; on the other hand, once it gelifies, it will remain firm at about the same temperature, usually 37° C., at which the pathogenic forms are generally incubated. The reversibility of the agar gel enables the operator alternately to warm it into the sol state and cool it into the gel state. Its firm, rubbery surface is not easily ruptured when organisms are streaked across it by needle. Pure agar gel is nearly transparent and neutral in reaction. All these unique characteristics of agar make it unexcelled as a bacteriological medium. It is also widely used in the preparation of semi-solid media. Having a ten times greater jellifying power than gelatin, it is a much cheaper material to use Nowadays, not only bacteriologists, but also other microbiologists, as well as scientists working on pure culture and life history of fungi, algae and even orchids, have to depend greatly on agar media.

*As Laxative.* The popular use of agar as a laxative is based on its ability to absorb and hold water, becoming at the same time a lubricant and a mild stimulant. For this purpose it may be taken in various ways—

PRINCIPAL AMERICAN AGARPHYTE
A FEMALE PLANT OF *Gelidium cartilagineum.*



"HAIR AGAR"
AN ASEXUAL PLANT OF *Gelidium nudifrons.*

with cream and sugar, or in special chocolate-coated preparations, or as a mineral-oil emulsion. *Merck Index* remarks that "unlike drug cathartics, it is not habit-forming, and does not lose its efficiency or require increasingly larger doses." According to Chase, quoting Caravaggi and Manfredi, agar also contains certain laxative and purgative principles which act uniquely on the intestine by exciting peristalsis without affecting the functions of the stomach or the duodenum.

*In Dental Impression Mold.* In dental work agar has proved to be the best material for making impression mold. Although materials made of algin are recently being used to take the place of agar, dentists mostly agree that, if the latter were available, they would go back to it. The value of agar gel lies in its having a long temperature lag between liquefying and hardening, which factor is very important in this kind of work. For this purpose generally a very concentrated agar gel is used to which a dye and a disinfectant are added. In using it a small portion of the preparation is heated to become a fluid, cooled down to about room temperature, placed in the tooth socket or in the oral cavity, cooled thoroughly, and upon solidification the wanted impression is obtained.

*Other Medical Uses.* Agar has long been used to stabilize an emulsion to carry vitamins and other items like acidophilus milk. It has also served in wound dressing on account of its inhibitory action on blood-clotting. Used in a preparation applied beneath the bandage, it helps to quicken the healing process. Glycerine suppositories have been made with agar as a vehicle. In obesity it is said to be useful. According to *Merck Index* it is also used in glycerine jelly for chapped hands and in prosthetic work in surgery.

### Agar as Food

*As Food in the Orient.* Agar has been and is used as a food in a great variety of ways in China and Japan. It should be noted, however, that agar has little nutritive value. A "food" in an Oriental sense may not necessarily be nourishing. Only the principal foods, like rice, need have nutritive value. The complementary foods, such as agar, may be merely appetizing. Up to the

early part of this century China had been importing from Japan annually over a million pounds of this commodity entirely for food. It is frequently served as a substitute for the expensive birds' nests. For this purpose the best grade of agar, which will not dissolve too readily in the hot soups, has to be used. It is also used in a special kind of "cold dish"; the agar strips are cut into smaller pieces, washed by soaking in cold water, placed in hot water, taken out before they show any signs of going into solution, and then mixed up with some good grade of soya sauce, some black vinegar and sometimes a few other ingredients such as red pepper. In Japan, agar is also cooked with rice, and with seasoning it forms an "agar-rice." Sweetened and flavored agar-gel is a favorite "cool diet" in the summer in hot countries such as South China and Malaya.

*As a Food Adjunct.* In recent years agar has been used extensively as an adjunct in various food preparations. Generally speaking it serves as a substitute for gelatin where the latter, for one reason or another, is unsuitable; it has also proved to be very economical, since, on account of its high gel strength, a relatively small amount is needed. It is used in confectionery throughout the world wherever agar is known. The confectioner can make a healthful jelly candy with less sugar by using agar in about half to one percent solution. In the preparation of drinks, such as malted milk, it provides a healthful body and acts as a stabilizer. Added to bread and pastries it helps to keep them from drying out, on account of its moisture retaining ability.

In the manufacture of frozen dairy products, agar has been most successfully used in sherbets and water-ices. It makes them smooth and prevents the drainage of unfrozen sirup out of them in the hardening room. Unlike gelatin, it acts quickly, and aging of products containing agar as the stabilizer is unnecessary. It making ice cream it also imparts a smoother texture to the preparation. The use of agar has helped to make a firmer bodied cheese of improved slicing qualities. Desserts and salad jellies made with agar have the distinctive advantage of setting rapidly and certainly, even in very warm climates. Being unassimilable and having high water absorbing capacity,

AGARPHYTES GROWING ON ROCKS NEAR LA JOLLA COVE, CALIFORNIA
*Gelidium cartilagineum* FLOURISHES IN EXPOSED PLACES WHERE WATER IS TURBULENT AND FAST.

it is an excellent roughage, recently used extensively in many breakfast and "health" foods.

*In Meat and Fish Canning.* In terms of agar consumption per capita, Australia is second only to Japan, using about fifteen hundred thousand pounds, or about 0.25 ounces per person per annum. The major part of this agar is said to be employed in meat and fish canning. It helps to keep the softer types of meat and fish from falling apart. Its ability to retain its gelatinizing power in a greater extent than animal gelatin, after subjection to the high temperature necessary in processing these foods, makes it superb for this particular purpose. New Zealand normally uses thirteen tons per annum for canning sheep's tongues. It is the writer's conviction that the use of agar in meat and fish canning will become more and more popular in the years to come. At present it is not being utilized in this way in this country as much as it should be.

*In Meat and Fish Preservation.* Agar provides a rather simple but effective way of temporarily preserving easily spoiled foodstuffs like meat and fish. It is especially recommended for hot countries where refrigeration is not available. The meat to be preserved is cooked with some agar and the resulting meat-gel will remain wholesome for quite a long time. The agar is not attacked by most putrefying bacteria, and thus it helps to prevent the entrance of oxygen and bacteria which will otherwise spoil the meat.

## Agar in Industries

In early days agar was extensively used in oriental industry in fabric sizing and in rendering rice paper more durable. It was also employed in making waterproof paper and cloth, which were used in China to wrap expensive porcelains and bronzes for exporting to Europe. In other countries such waterproof wrappings also served to prevent corrosion of munitions.

At present agar is still being used in the textile industry, but only in silk sizing and in the warp of silk. In the modern paper industry agar is utilized to some extent as a paper coating to impart resistance to the penetration of resin, wax and grease. It is used to make the gelatinous rolls in hectograph duplicators. In the tanning industry, it serves to impart a gloss and stiffness to leather in the finishing process. It is employed as an ingredient of calcimine and shoe stains. Occasionally it is also used in the making of molds required by workers in plaster of Paris.

Agar also renders its services to agriculture as a supplement in nicotine sprays for insect pest control. In the cosmetic industry agar is used as the base of certain non-grease preparations, shaving soaps and hand lotions. It is also employed as a binder in certain dentifrices. The least expected, but important, use of agar is in the electrical lamp industry. In the hot drawing of tungsten wire, a lubricant is necessary to facilitate the drawing operations and reduce the wear on the die. Westinghouse uses a lubricant made of homogeneous suspension of powdered graphite in agar gel. In Japan, agar is also employed in making electric lamp shades.

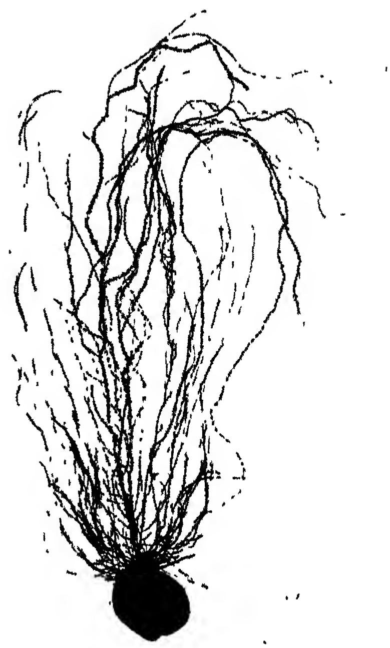
Among the recently discovered promising uses of agar is its application in making photographic plates and films. Actually, more than twenty years ago patents were already issued in Germany covering such use of agar. That agar was not extensively used for this purpose was due to the fact that certain chemicals present in gelatin, but not occurring in agar, were necessary in making the sensitive emulsion. Recently it was found that these substances could be successfully added to agar. With this problem solved, agar is said to be superior to gelatin for photographic films because an agar film need be only one eighth the thickness of a gelatin film, is less soluble in water, does not melt in the tropical heat, and is cheaper. One firm is said to assert that agar is a better substance for supporting sensitized emulsion than any similar material now on the market.

There are undoubtedly many more uses of agar of which the writer is not aware and the number of its uses is expected to increase. At present no published data are available as to the amounts of agar used annually for the above mentioned purposes. According to information from agar dealers and various other sources, the 650,000 lbs. of agar used annually in the United States before the war were distributed approximately as follows:

| | |
|---|---|
| Laxative | 100,000 |
| Microbiological culture medium | 100,000 |
| Bakery | 100,000 |
| Confectionery | 100,000 |
| Dental impression mold | 75,000 |
| Meat packing | 50,000 |
| Emulsifier | 50,000 |
| Cosmetic | 25,000 |
| Miscellaneous | 50,000 |

### Kinds and Sources of Agarphytes

There is a good deal of misinformation regarding the different kinds of commercial agarphytes and their geographical sources. *Gracilaria lichenoides* (=*Sphaerococcus lichenoides, Plocaria candida*), which has undoubtedly been mentioned the most frequently by writers reporting on agarphytes, is actually a very unimportant and negligible source for commercial agar. Another commonly cited plant for making agar is *Gloiopeltis tenax* (=*Sphaerococcus tenax, Plocaria tenax, Gigartina tenax, Gracilaria tenax*). It has never been used for this purpose. The genus *Gigartina* has been credited with a share in agar manufacture; again, not a single species has ever been commercially utilized in this manner, so far. The "Gelidium corneum," supposed to be the principal agarphyte, is still a taxonomic mystery remaining to be solved; it should be removed from the list of agarphytes until its true identity is revealed. According to Kizevetter and others, *Phyllophora rubens* is used in making "agaroid," which may not be a true agar, and is therefore excluded at present.



AGAR-PRODUCING SEAWEED
*Gracilaria confervoides* FROM SAN DIEGO BAY.

The list of agarphytes is certainly a lengthy one. There are, however, only a few which can be said to be the principal sources of agar: *Gelidium Amansii, G. cartilagineum,* and *Ahnfeltia plicata.* Besides these there are about forty other red algae, most of which are used merely as supplementary materials to mix with the principal agarphyte in agar manufacture. The American factories use almost exclusively *Gelidium cartilagineum* (L.) Gaill. which forms the "agarweed" of the commercial divers.

# ELECTRIC WAVES—LONG AND SHORT

By J. O. PERRINE

Of all the tools of war and peace now doing valiant service, there is none more potent and versatile than the electric wave. In the past the natural sound waves of human speech and the natural light and heat waves of the sun and, of course, the water waves of the seven seas were the principal waves which touched life. Prior to the nineteenth century artificially made electric and sound waves played a minor role in peace and war. Today waves of many kinds—long waves, short waves, and microwaves of sound, heat, light, and electricity—engage the efforts of scientific workers of university and industrial laboratories.

These waves make new environments for all people. The word "wave" itself has a place in the vocabulary of laymen as never before. Waves have become more and more a commonplace in peace times. In 1943 waves, particularly artificial electric waves, went to war.

### Electric Waves of Many Lengths

For the needs of home and industry and on the war front, long electric waves carry large amounts of power for heat, light, and machines. The sixty cycles per second wave guided by the high tension lines of the power engineer is five million meters long. Expressed in English units, it is 5,468,000 yards long.

Likewise, for the needs of home and industry and for the conduct of the war, a great array of electric waves bearing small amounts of power are used in the communication systems in all parts of the world. Each day millions of messages are borne by both the guided and unguided waves of telegraph, telephone, and radio. In general the radio waves in these day-to-day practical fields range from five meters to thirty thousand meters in length, and up to one million meters for speech waves and telegraph waves on wires. Those waves sometimes referred to over the radio as short waves and used for transoceanic communication, range from about five meters to about twenty meters. Standard broadcasting uses waves from five hundred and fifty meters to sixteen hundred meters.

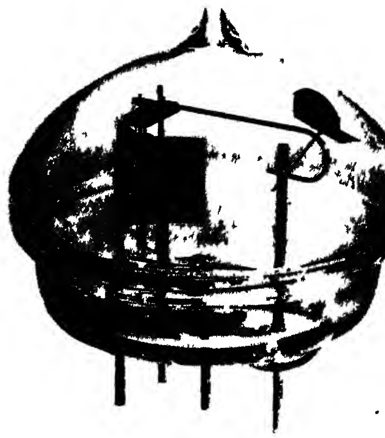
At the other end of the gamut of electric waves are the micro-microscopic waves of X-rays and those emitted by radium, called gamma rays, both of which may heal the wounds of man and give information concerning the nature of the physical world in which he lives. The shortest waves that have been found by the inquisitive mind of man are not the very short waves of X-rays and radium but rather those known as secondary cosmic rays. Contrasted to the sixty cycles per second (in some cases twenty-five) and the five million meter wave of the power engineer, the secondary cosmic rays have frequencies as high as one million million million cycles per second and wavelengths as near the nadir of nothingness as .000,000,000,000,3 millimeter.

### Octaves of Waves

In the realm of vibrations, the octave is the well-established term used to indicate a frequency which is twice greater than some other frequency. The term is usually applied to the sound vibrations of music in which a note having twice the frequency of another is said to be an octave above it in pitch. On the piano there are about seven octaves, thirty-two to 4,096 vibrations per second; 32, 64, 128, 256 and so on to 4,096. Although the octave denotes a one hundred percent change in pitch, the higher note of a pair of semi-tones, anywhere within the octave of the musical scale, is six percent greater in frequency than the lower note. The human ear can hear frequencies from about sixteen to eighteen thousand, a range of ten octaves. Using this concept of octave to help appreciate the amazing breadth of the array of electric waves known to man, we find the gamut of electric waves, long and short, to be about eighty octaves.

### A Family of Electric Waves

It was a great sally of imagination when



THIS VACUUM TUBE OSCILLATES AT 740 MILLION CYCLES PER SECOND
WAVELENGTH 40 CM. 2½ INCHES IN DIAMETER.

man first regarded a wide variety of seemingly different kinds of waves as examples of one great category, the electromagnetic. Visible light, ultraviolet waves, infrared waves, heat waves, electric waves, X-rays, radium rays, and secondary cosmic rays are, after much study and reflection, regarded as waves of the same kind. Their distinguishing physical characteristics are wavelength and frequency of vibration. Their origins are different, their capabilities are different, their uses are different, but all are members of the same family.

An outstanding property of all the waves of the electromagnetic family is their amazing swiftness of flight. No other kind of waves, no projectile, vehicle, or moving thing in the entire universe travels so fast, namely, one hundred and eighty-six thousand miles (three hundred million meters) per second. The telephone, the telegraph, the radio, television, the radar, the X-ray, the camera—all do their tasks so marvelously because of the incredible speed of electric waves. A poet wrote many years ago about the telegraph:

The electric nerve whose instantaneous thrill makes next door neighbors of the antipodes.

### Infrared and Ultraviolet

The background and basis for our comprehensive concept of electromagnetic waves began about 1800. At that time, as for centuries before and centuries to come, the visible spectrum as seen in the rainbow was and ever will be a thing of sublime beauty. By the simple means of a triangular glass prism, sunlight can be readily split into several colors This artificial experiment provided an explanation and understanding of the natural rainbow. Newton made that great contribution in 1666. We now know that the colors of the rainbow extending from red light to violet cover only a single octave of vibrations, namely, three hundred and seventy-five million million to seven hundred and fifty million million. In wavelength, visible light varies from .0008 millimeter in the red to .0004 millimeter in the violet. It is surprising and stirring that this one octave makes possible so much beauty of tint and shade. One octave of sound would surely not be enough for a Beethoven or a McDowell.

In 1800, the elder Herschel repeated the experiment of Newton. But he did more than merely repeat an experiment. He obeyed an impulse to try something new. He held a thermometer in the streaks of color streaming out of the face of the prism upon a white cardboard to find out about the relative amounts of heat. He discovered the violet to be the coolest and the red to be hotter. But the drama does not stop there. He was happily surprised to find that his thermometer indicated still higher temperatures in a region outside the band of visible light and adjacent to the red rays. The invisible longer rays were called infrared rays. Here was a totally unexpected epoch-making discovery—not all of the spectrum of waves in sunlight was visible.

Soon afterward another invisible extension of the spectrum was discovered outside the angle of emergence of the violet light. It was called the ultraviolet. It is a surprising fact that only a small portion of the sun's radiation is in the visible spectrum; most of it is invisible. The infrared extends about seventeen octaves below and the ultraviolet about six octaves above the sides of the one octave of visible colors.

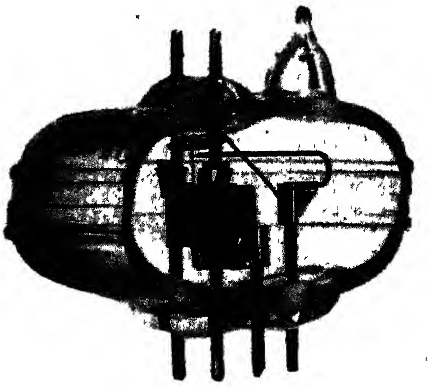
### Light Waves Are Electromagnetic

No further additions were made to the radiation spectrum for half a century. It is likely, furthermore, that the existence of other waves was not even suspected. However, in 1866 there occurred a most significant episode in the saga of waves. Clerk

Maxwell, a Scoth mathematician and natural philosopher (now called a physicist) working at Cambridge University, England, made the first great sortie of speculation regarding visible light and its two neighbors, the infrared and the ultraviolet. He proposed that these three radiations, generally called light, were electromagnetic in character. Electricity and magnetism were then, and are now, fertile subjects for theory and experimentation. Magnets and electric charges had been found to have regions of disturbance about them, fields of influence extending into space. To Maxwell and his predecessor, Faraday, the fundamental reality was neither the physical piece of iron called a magnet nor the electrically charged metal sphere. The real crux of the phenomenon was the regions of space around the magnet, on the one hand, and around the charged sphere, on the other hand. There was a sort of radiation field of influence present in each case. The fields were quite distinctly different in character, one magnetic and the other electric, detectable by intrinsically different techniques. There was a suggestion of waves in these fields. With much observation, meditation, and mathematics, Maxwell suggested that electromagnetic waves might exist and, furthermore, that light waves were really electromagnetic in character. He made the scintillating prediction that electromagnetic waves, longer than the infrared, might be produced artificially and that they might be detected by distinctively electromagnetic means.

### Discovery of Radio Waves

Twenty years later, in 1895, Heinrich Hertz, a German natural philosopher working at Karlsruhe with simple apparatus and electrical arrangements, produced and transmitted electric waves, and proved he had done so by receiving and detecting them with electrical apparatus. Hertz had brilliantly confirmed the startling prediction of Maxwell. Hertzian waves were sent through space fifty feet without wires. Their wavelength was fifteen feet corresponding to sixty million cycles per second. It was indeed an important milestone in scientific history, the peer of any political or military episode. It is interesting that the first electric waves

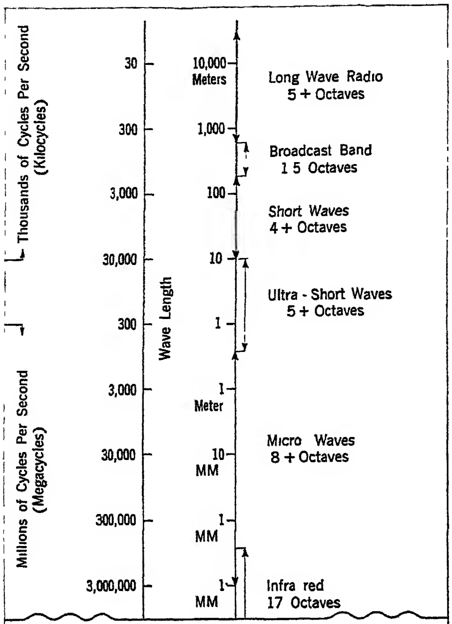


ELECTRON TUBE FOR THE PRODUCTION OF 2000 MILLION CYCLES A SECOND WAVELENGTH 15 CM. 2 INCHES IN DIAMETER.

ever produced were short waves, as we think of them today. Hertz later produced ultrashort waves of five hundred million cycles and twenty-four inches (600 millimeters) in length.

### Heat Waves Meet Electric Waves

Maxwell and Hertz, combining great analytical talent and experimental skill, had erected a great amphitheatre of knowledge out of which opened many doors. The electromagnetic spectrum became a fertile and challenging field of research. There were the natural means of short-wave production such as the sun, glowing embers, and the ordinary flame. By artificial means, long electric waves could be produced. The provocative question was, could all wave-lengths and frequencies be produced? Could waves be made by electrical means so short that they might even be called heat waves? Could heat waves be made so long that they might be called electric waves? It was a thrilling search for electromagnetic waves of intermediate length to bridge the gap between Hertzian waves and the longer infrared light waves. For several years the short electric wave record was held by Bose, of India, who produced and measured electric waves 75,000 million cycles per second and four millimeters long. The electrical vibration frontier moved forward slowly. To attain waves .22 millimeter in length required another twenty years of research.



ELECTROMAGNETIC WAVE SPECTRUM

During the same interval of about twenty years following Hertz, similar progress was being made in the discovery of long heat waves. At first progress was rapid. By 1900, far infrared frequencies of roughly three million million cycles and one-tenth millimeter in length had been attained.

In 1910, E. F. Nichols, then of Columbia University, made notable progress by producing and measuring long heat waves of four-tenth-millimeter. He used sensitive thermocouples (electrical thermometers as detectors). The same method, but with cruder instruments, had been used by the elder Herschel a century before.

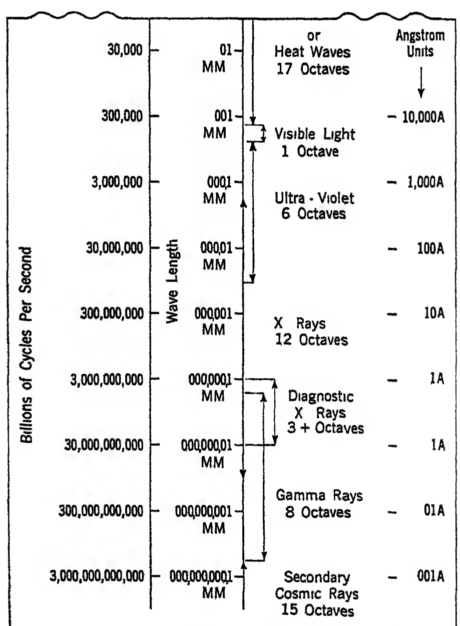
The gap between four millimeters and four-tenth millimeter does not seem to be a wide gap. It is over three octaves, however, over three times as wide as the entire visible spectrum. This unexplored gap resisted all efforts to bridge it for another decade.

The final bridging of the gap came in 1924. Again Professor Nichols and his co-worker, Dr. Tear, succeeded in extending both frontiers. Longer heat waves were produced and measured, and shorter electric waves were produced and measured. The gap was not only bridged but also overlapped about an octave. Electric waves of the amazingly small wavelength of .22 millimeter and heat waves .42 millimeter were produced. Shortly afterward Arkadiewa, in Russia, succeeded in producing electric waves .08 millimeter long. Through the years scientists had the will, the brains, and the skillful techniques to fill out the spectrum between heat waves and electric waves. Their success was of great practical value as well as a notable scientific achievement.

Today Hertzian waves, radio waves, or electric waves, by whatever name one wishes to call them—one may always properly call them electromagnetic waves—are produced by laboratory means over a range of twenty-five octaves. In this broad span, many times the visible spectrum in length, these waves vary from about thirty kilometers (one kilometer equals .62 miles) to .1 millimeter (twenty-five millimeters equal one inch). Expressed in vibrations, this would be a range of ten thousand cycles per second to three million million cycles per second.

## X-Rays

The thrilling achievement of the production of all electromagnetic waves of greater wavelength than red light is matched by the success in electromagnetic wave production in the region shorter than the violet light. As



ELECTROMAGNETIC WAVE SPECTRUM

has been stated, the ultraviolet region covers about six octaves of waves shorter than the violet. The longest ultraviolet wave is about .0004 millimeter and the shortest is about .000,003 millimeter.

In 1895 Roentgen discovered a "new kind of light," a hitherto unimagined and unpredicted kind of radiation. He was experimenting with the action of electricity in vacuum tubes. Much was known about the general behavior of electricity, how it served man, how it performed certain tasks, but not much was known about electricity itself. The passage of electricity through wires and liquids gave no clue as to its real nature. However, the visible effects disclosed when it was sent through various gases in vacuum tubes gave promise of finding out its intrinsic character. The situation was prophetically and elegantly described by Sir J. J. Thomson in 1893:

> The phenomena attending the electric discharge through gases are so beautiful and varied that they have attracted the attention of numerous observers. The attention given to these phenomena is not, however, due so much to the beauty of the experiments as to the widespread conviction that there is perhaps no other branch of physics which affords us so promising an opportunity of penetrating the secret of electricity; for while the passage of this agent through a metal or an electrolyte is invisible, that through a gas is accompanied by the most brilliantly luminous effects, which in many cases are so much influenced by changes in the conditions of the discharge as to give us many opportunities of testing any view we may take of the nature of electricity, of the electric discharge, and of the relation between electricity and matter.

In tune with the J. J. Thomson philosophy, Roentgen had been working with a Crookes tube, a form of vacuum tube containing gas at low pressure. Carefully covered photographic plates were found to be blackened when accidentally left lying near Roentgen's apparatus. Not knowing what the radiation was, he called them, probably as a result of his studying algebra in his school days, X-rays, unknown rays.

These X-rays penetrated and passed through wood, paper, flesh, and many materials opaque to visible light. It was natural to think of them as a "new kind of light." It was believed that they were electromagnetic waves, since Maxwell's suggestion that light waves were electromagnetic and his prediction, substantiated by Hertz's experiments, that longer waves could exist, had been generally accepted. If X-rays were a kind of light wave, then they should exhibit one of the simplest phenomena of light, namely reflection. All attempts to reflect X-rays failed and continued to fail for seventeen years. Then the brilliant flight of imagination of another physicist, Laue by name, gave a clue as to the reason for failure. He suggested X-rays were many-fold shorter than visible light. All the reflecting surfaces that had been used were literally too rough. For sound waves several feet long, a brick wall, layer upon layer of brick with mortar between, is relatively a smooth surface and so sound echoes result. For very short light waves, .0004 millimeter in length, the layers of brick and their intervening strips of mortar are too rough for regular reflection. One must have a highly polished surface. According to this principle, Laue said X-rays are so very short that even the most highly polished mirror attainable was still too rough.

In the intervening years atoms and molecules, the beautifully symmetrical crystals of rock salt, quartz, and other materials had been the subject of many researches. Laue therefore further suggested that the atoms in crystals might stand in rank and file like the bricks in a brick wall, however, with no mortar between them. Since they were so small themselves their rank and file, their façade, not the outside surface of the crystal but the façade of the atoms within the crystals, would be smooth enough and regular enough to reflect X-rays.

In 1912 the first experiments to test this conjecture were tried. From the very beginning they were a brilliant success. A great scientist's brilliant speculation had brought a great advance. X-rays falling on crystals were reflected. Furthermore, they were diffracted, that is, bent around super-sharp corners as are water waves around the end of a pier. For many years X-rays had been a sort of scientific waif, with an anomalous given name, "a pulse in the ether." In 1912 they were given a surname, Electromagnetic Wave. X-rays became a member of the family of light, heat, and radio waves. Their wavelengths had become measurable and, as predicted, were found to be shorter than those of ultraviolet light. The less pene-

trating ones known as soft X-rays are about .000,000,4 millimeter. Diagnostic and therapeutic X-rays, more penetrating, or "hard," range from .000,000,1 millimeter to .000,000,01 millimeter. As other gaps have been closed, so the gap between X-rays and ultraviolet light has been successfully bridged. In fact, the longest X-rays have not only met the shortest ultraviolet but have also substantially overlapped. X-radiation covers about ten octaves.

The cases of radio waves and X-rays present an interesting contrast. Radio waves were predicted twenty years before they were found to exist, 1866 (Maxwell)—1886 (Hertz). X-rays were experimentally produced seventeen years before their real identity and character were understood, 1895 (Roentgen)—1912 (Laue).

It is particularly interesting that although crystals were used to study X-rays at the start, in later days X-rays were used to study crystals. These researches have penetrated crystals and determined the groupings of the atoms of which they are composed, the distances between their atoms, and the directions they are located one from another.

## Gamma Rays

Radio waves of useful character and X-rays are splendid examples of the ability of man to produce waves which are not made in nature's workshop. These two groups of waves of widely different wavelengths are entirely artificial. Imagination and constructive skill have produced important electromagnetic radiations that nature does not manufacture. One might argue that lightning flashes are accompanied by radio waves and that nature does, therefore, manufacture static radio waves. But at least useful radio waves and electricity as a tractable and serviceable agent are not part of nature's bounty. Useful X-rays, then, are strictly artificial; they are not produced anywhere in nature and are not the accompaniment of any natural phenomenon.

However, nature does manufacture electromagnetic waves similar to X-rays but considerably shorter. These waves are called *gamma rays*. They were discovered, interestingly enough, only one year later than X-rays. In 1896, Becquerel observed the phenomenon of radioactivity, a field in which Madame and Pierre Curie carried out brilliant researches and discovered and isolated the principal exhibitor of radioactivity, radium. In the process of radioactivity, there is a spontaneous breaking down of matter, an atomic volcanic action. Accompanying the disintegration of heavier atoms into simpler and lighter atoms, the gamma ray, a different "kind of light," is emitted. Since ordinary light accompanies the rapid vibration and scurrying about of atoms in incandescent lamp filaments and glowing metal and heated objects in general, it is not surprising that during an atomic explosion there should be some sort of electromagnetic radiation. The gamma rays are super-short and are readily detected and measured. Their wavelength is in the neighborhood of .000,000,003 millimeter and covers a range of about eight octaves. The X-ray spectrum and the gamma ray spectrum overlap in the region of the shorter X-rays. The therapeutic effect of radium involves the gamma rays, which are generally comparable in wavelength to the shortest of the therapeutic X-rays.

## Secondary Cosmic Rays

Finally in the field of electric waves, long and short, are the secondary cosmic rays. Their spectrum extends far out from the shortest gamma rays for some twelve or fifteen octaves. As has been stated, the frequency of the shortest radio wave capable of being manufactured is three million million cycles per second and a fraction of a millimeter in wavelength. The frequency of the secondary cosmic ray may be as high as a million million million million cycles per second, which corresponds to an incredibly small wavelength.

Primary cosmic rays are apparently high-speed particles which come to our earth from the interstellar regions and perhaps from beyond the borders of our Milky Way system. When they strike our atmosphere, secondary cosmic rays are produced. These latter rays possess great energy and are capable of passing through several feet of lead. Radio waves, long and short, travel long distances through air and pass through many mate-

rials. Heat waves, light waves, ultraviolet waves, X-rays, gamma rays—all penetrate various substances. The secondary cosmic rays, micro-micro waves, are the most penetrating waves of all those yet discovered. They have been detected in the deepest mines and deepest lakes after having passed through hundreds of feet of rock and earth and water.

### The Qualities of Electric Waves

Like the members of a human family, the members of the electromagnetic family exhibit widely varying qualities and capabilities. Different parts of the spectrum must be studied by different methods and with different apparatus. Different parts are useful for widely different purposes and some parts are not as yet used at all. The very long waves of the power engineer perform arduous tasks and do lots of work in home and industry. They are studied with meters to measure amperes, volts, and watts. Only one-fourth of the eighty octaves of the spectrum are used in communication to carry code messages on the one hand and facsimiles of speech and music on the other hand. Sizable meters of various kinds are used in this field, too. In the radio region electrical resonance, or tuning, is the technique of reception and detection. The measuring instruments are of the same type but not as large. As the shorter waves were mastered, a sudden and drastic change was necessary in the instrumentalities of study. In the far infrared, the thermometer, particularly the sensitive electrical thermometer, is the detecting device. In the near infrared, either a thermocouple or photography is used. Several methods are available for research in the visible spectrum, including human vision. But since the eye is unreliable for purposes of measurement, thermocouples and photoelectric cells, and most of all photographic plates, become necessary tools. For the ultraviolet and X-rays, photography is commonly used.

The ultraviolet has sun-tanning and blistering effects and certain wavelengths have germicidal effects, but for quantitative study nothing else is quite so satisfactory as photography. The ordinary photographic film is very sensitive to ultraviolet light; less sensitive to the blue-violet of the visible spectrum; and rather insensitive to the red.

Some living organisms are not only benefited but also dependent upon light for growth; others are killed by visible light and ultraviolet; some compounds will literally explode when light strikes them. The tissue of the human body is unaffected by radio broadcast waves but is warmed by infrared waves and is stimulated and even burned by light, ultraviolet waves, and X-rays.

In addition to the many so-called practical uses of the waves of the electromagnetic spectrum, a study of this spectrum has made possible an outstanding contribution toward a further basic understanding of the world in which we live. The ever engaging and challenging question has been, What is matter? Light waves, heat waves, infrared waves, X-rays, and all the other frequencies give clues as to the arrangement and motion of atoms and molecules and electrons. They are all tools which have supplied new and stimulating knowledge as to the intrinsic nature and architecture of matter.

The qualities of gamma rays and cosmic rays are most reliably studied by means of the ionization chamber. When these rays penetrate a gas enclosed in a tube, that gas is made a conductor of electricity; the device is called an ionization chamber and becomes the instrument for measurement.

X-rays and the gamma rays of that amazing element radium are both remedial and dangerous. They destroy good tissue as well as diseased tissue and germs of every kind. The goal of the physicist and the biologist is to find the technique of measurement and dosage that will take more and more advantage of the fact that these radiations destroy diseased tissue a little faster than healthy tissue.

All of the waves in the electromagnetic spectrum carry power. They are all forms of radiant energy. They are not of themselves color, they are not light, chemical action, heat, photoelectric effect, or sunburn. When waves bearing widely varying amounts of power and oscillating with widely varying frequency are received, the effect produced by them in the receiving material or receiving device may be heat, light, color, speech, music, chemical or physiological change.

The effect produced depends almost as much on the receiving device as it does on the frequency involved. Of course, one would hardly expect the ultraviolet rays of the sun to actuate a radio receiving set or radio waves to tan the human skin. However, with the provision of the appropriate transmitter and receiver, ultraviolet waves have been used to carry speech and music for a distance of a hundred feet. Infrared light, quite invisible to the eye, has been used for secret signaling in daylight and darkness.

### Production of Radio Waves

The first method of achieving the manufacture of electric waves (1886) took advantage of a phenomenon well known for more than fifty years. In 1827, Savery of France discovered that the electric discharge of a condenser, of which a Leyden jar is a good example, is oscillatory. According to this method two conductors, for example two spheres or two parallel plates of metal, were given a high-voltage charge by means of a static machine or induction coil. When the charge was raised to a high-voltage level, a spark jumped across. Electrical vibrations were thus manufactured.

An analogy may help one to get the idea of an oscillatory discharge. A tall tank of water is connected to another empty tank. A closed valve in the connecting pipe is opened; it might even be broken through by the pressure of the water. Water would rush out of the full tank up into the empty tank and then back into the original tank. There would be a series of water current oscillations. Now the condenser is a sort of pair of electrical tanks. During its discharge electrical currents oscillate back and forth between the two metallic surfaces. As stated, Savary first discovered this oscillatory character of a condenser discharge with a spark visible at the gap. Accompanying the rushing of electric current back and forth, electric waves are radiated. Lord Kelvin first set up and solved the mathematical equations for such electrical vibrations. His explicit mathematics of 1853 still is valid to calculate the frequency and wavelength of electric waves.

This basic method of condenser discharge was the one originally used by Hertz and and later by Marconi. It was the accepted method for radio telegraphy for many years but could not be used for radiotelephony. We now know that the lightning flash is oscillatory; so Dame Nature, using the cloud and the earth or two clouds as plates of a condenser, had the technique before Savary, Joseph Henry (who in 1842 made important contributions in this field), Lord Kelvin, and Hertz.

A second method was that of the rotating electrical dynamo. It is the method which has ever been used for the production of the sixty-cycle alternating current to supply light, heat, and power. High speed rotating dynamo electric machines were designed by Fessenden (1907), Alexanderson and Goldsmidt to produce, for the purposes of radio telegraphy, frequencies in the neighborhood of one hundred and fifty thousand cycles per second, two kilometers in wavelength. These electric waves were very long.

### The Era of Electronics

The X-ray was the result of research concerned with the study of electricity in a vacuum. Out of that research and philosophy expressed by Sir J. J. Thomson came that modern Aladdin's Lamp, the electron tube.

The tradition of research on electricity unassociated with ponderable, sluggish, and hampering atoms of matter, on electricity per se performing in a vacuum tube, on electrons, so brilliantly begun by Crookes, J. J. Thomson, Roentgen, Becquerel, Edison, and many others before 1900, has been carried on with equal brilliance by their successors. Fleming, Millikan, Richardson, Carty, Lorentz, de Forest, Arnold, Langmuir, Jewett, and many others have exhibited magnificent international teamwork in putting electrons into useful service.

During the televictorian age of the last years, the limitations of time and space have been erased because electric waves of many lengths and many frequencies have been revealed as pearls without price in nature's bounty. They became a useful reality when an atom of electricity, an electron, electricity its very self was put to work inside a vacuum

tube. Our planet has become "one world" largely because of electric waves. The tele-victorian age, the electric wave age, and the electron tube age have become synonymous.

First used in a practical way as an amplifier in 1915 at intervals along the telephone line to span the United States, the electron tube has become an essential device in thousands of miles of long-distance telephone lines throughout the world. Contemporarily, it was recognized as a most important actor in both transmitter and receiver in radio telephony, radio telegraphy, and radio broadcasting. Today it is aptly applied to a thousand and one other tasks. Associated with proper electrical wire circuit arrangements and electric power supply, the vacuum tube can generate electric currents; it can also mold electric currents, amplify electric currents, rectify electric currents, and detect electric currents. In many ensembles of high-frequency equipment today, it likely performs all five functions. In its role as an oscillator, as a generator of electrical vibrations for communication, it plays the part of a virtuoso for the manufacture of twenty octaves or more of electric waves. Armstrong, de Forest, Colpitts, and Hartley were pioneers in this field. Many others later made further contributions to the operating techniques and apparatus for the creation of electric waves by electron tubes and associated circuits. In many ingenious designs and forms, the electron tube circuit generates electric waves from sixty cycles per second to 500,000 million cycles per second—in wavelength, from five million meters to six millimeters.

By wire and radio, millions of telephone and telegraph messages are carried each day; electrical echoes, as utilized in the recently announced radar, detect and tell the distance and the angle of the approaching ship or airplane; light waves give vision and carry messages; heat waves transmit warmth and help the earth to be the good earth with its abundant harvest; portable X-ray equipment on the field of battle enables the injured to be restored to health; gamma rays of radium heal wounds; and cosmic rays stimulate the imagination as to the nature of the world in which we live. Electromagnetic waves, long, short, ultra-short, micro and micro-micro—eighty octaves of them—intangible, imponderable, mostly invisible, inaudible, constantly the subject for research and investigation throughout the world, are the talented and versatile members of a most fascinating family now playing a conspicuous role on home fronts and on war fronts.

# TROPICAL MEDICINE: ITS SCOPE AND PRESENT STATUS*

By ELLIS HERNDON HUDSON

MEDICAL and lay attention is now being directed toward tropical medicine in unprecedented degree. Admiral Stitt, looking back over the past fifty years, recently traced the curve of interest in tropical medicine through three wars. During the Spanish-American war, malaria, yellow fever, and the dysenteries were to the fore. The subsequent cutting of the Panama Canal, the occupation of the Philippines, and operations in the West Indies kept interest in tropical diseases on a gradually rising curve. The World War of 1914–18, however, was fought—at least by American forces—in temperate zones, and Stitt points out that the focus of medical attention was transferred to meningitis, trench fever, and the pneumonias—streptococcal, pneumococcal, and influenzal. During the inter-war period, for two decades after 1919, tropical medicine made steady progress but was overshadowed by other branches until a few years ago, when it was realized that, for Americans at least, the approaching second world war would be fought to a large extent in the tropics and subtropics. With the establishment of American troops in the Caribbean and Mediterranean basins, in India, China, and the East Indies, and the southern Pacific, the curve of interest has again turned sharply upward.

*Is this Country in Danger of Imported Exotic[1] Diseases?* Anxiety has been expressed lest the contact of American troops with tropical diseases abroad will react unfavorably upon the health of the people of continental America. This anxiety is to some extent justified. The two barriers of time and space which once kept diseases away from our shores have been abolished by the automobile and airplane. We read of a newspaper correspondent leaving Australia on Tuesday and arriving in San Francisco on Thursday, only seventy-two hours later. A Navy man comes to the Washington Dispensary with a sandflea (*Tunga penetrans*) between his toes; he acquired it in South America and returned by air before it manifested its presence. The Pan American Highway runs right through the region of Guatemala to which onchocerciasis (filariasis of the skin) has hitherto been limited. Even Bartonellosis (oroya fever, Carrion's disease), which has been found only in remote valleys of the high Andes, may become a general hazard by reason of military movements and modern methods of travel.

Many diseases which take time to develop used to be detected in travellers before their long homeward voyage was completed; now a man may contract malaria in India or the South Pacific and have his first chill in New York or Denver. From the standpoint of contagious disease new significance is added to the aircraft advertisement which states that no man on earth lives further than sixty flying hours from any American airport. The spread-rate of epidemics, such as dengue, influenza, and cholera, has always been in direct ratio to the rate of human travel; hence, many minds are preoccupied with the possibility of swift and overwhelming pandemics.

Another disquieting feature is that whereas tropical diseases were formerly imported into this country by the occasional "foreigner" or immigrant, they will doubtless be brought in during this war by thousands of our own men who will return to live in their "home-towns" scattered throughout the land. Further, it looks as if our commitments for stabilization and maintenance of peace after the war will involve us in such

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[1] The word exotic—used in antithesis to indigenous—is in some respects preferable to the word tropical. Many of the diseases now called tropical once flourished in temperate zones, and others even today are prevalent in temperate regions other than our own.

responsibilities in tropical countries that a constant stream of such infections will continue to be imported into this country for an indefinite period.

Though these are real dangers they can easily be exaggerated. Some medical and lay writing on the subject has been needlessly alarmist, and the other side of the picture needs to be emphasized. Many tropical diseases, especially of the metazoan parasites, are dependent for their propagation upon habits not found in this country. In this group are the flukes, dependent upon human consumption of raw fish and crabs; the intestinal roundworms, dependent upon the use of nightsoil as fertilizer, and the lack of personal and community hygiene; and the tapeworms, dependent upon human consumption of uninspected meat or the ingestion of food or water contaminated with animal droppings. In other diseases, such as trypanosomiasis, leishmaniasis, filariasis, and schistosomiasis, the vector or the intermediate host is either absent in this country or can be controlled by use of present knowledge or extension of present sanitary measures.

Even in the case of malaria, though new and possibly more virulent strains may be imported, and though there may be sporadic outbreaks, our health-conscious communities and efficient health services will keep the disease local and transient. Indeed, new knowledge of malaria now being gained in this war, in techniques of treatment and mosquito control, will tend to clear up much of the disease already existing on this continent.

There are two other favorable features. After the war many physicians will return to this country armed with experience in the diagnosis and treatment of tropical diseases. And secondly, there is much indirect evidence that temperate zone temperatures and climatic conditions per se have an unfavorable effect upon the propagation of tropical diseases.

In summary, one may well conclude that although the impact of tropical diseases on this country because of the war and its aftermath may be substantial, the dangers to our people can be largely avoided by the use of knowledge and facilities now in our possession. The converse of this fact is that the names and characteristics of many exotic diseases will have become familiar to millions of service-men and their families. Increased lay and medical interest is, no doubt therefore, only the prelude to expansion in this field of medicine in the United States.

The medical schools, while conscious of the present pressure on the medical student and curriculum, and the shortage of teachers, nevertheless recognize the necessity for instruction in parasitic and tropical diseases. In recent months existing courses have been strengthened, new courses have been introduced, special lectureships are being provided, teachers are being trained both in this country and abroad, information about exotic diseases is being pooled among the medical schools, and a distribution center has been established for specimens, pathological material, and visual teaching aids. This increased emphasis upon tropical disease has received the hearty encouragement of the Surgeons General of the Services, who for many years have been concerned with the training of young doctors in this field.

If, as Gregg has said, the next ten years will witness a revaluation and reform of the medical curriculum, the signs indicate that tropical medicine will have gained in stature in the process.

*Advantages to be Anticipated from Expansion of Tropical Medicine.* Some favorable features will result from this new and growing interest in the tropical field. First will come a greater appreciation of the importance of environment in disease. Earlier viewpoints stressed the static relationship of host, parasite, and environment. Later, fluctuation of both parasite and host was emphasized, but the molding influence of environment was slow to be recognized. Now, however, it is admitted that all three components of the disease picture are fluid entities and that the end result at a given time and place will depend upon their mutual influence. This concept is powerfully reinforced by a consideration of tropical disease, in which environmental and epidemiological factors occupy so prominent a place.

The second gain from the new interest in exotic diseases will be appreciation of the geography of disease, a science still in its infancy. The Germans were far ahead of us in this field, but their knowledge has been

perverted to base uses, political rather than scientific. There are two phases in this branch of medicine: disease distribution in relation to geography, and differences in the *same* disease as it appears at different places on the earth's surface. That is, we shall not only be interested in the "what, where, how, and why" of the diseases indigenous to the jungles of Brazil, the deserts of Africa, and the islands of the Pacific, but we shall also be concerned with the behavior of diseases more familiar to us, such as tuberculosis, measles and cancer, as they occur in the environments of regions so different from our own. Tropical medicine introduces us to the importance of *place* in pathology, and the diagnostic value of the question, where has the patient lived?

Thirdly, the mutual impact of tropical and temperate zone medicine is pregnant with possibilities in the field of research. On the one hand, tropical medicine is ten to twenty years behind in applying the techniques of modern investigative physiology, biochemistry, and pharmacology. Knowledge of the pathology, diagnosis, and treatment of exotic diseases is bound to increase rapidly as these techniques are applied to them. An amazing amount of unknown territory in tropical medicine can be taken over simply by the use of weapons which temperate zone medicine already has in hand.

On the other hand, research in tropical zones will stimulate all branches of medical research, not only because it offers an unlimited quantity of human material for investigation, but because the exaggerated conditions of disease found among tropical peoples will throw light upon the less easily analyzed disorders of temperate zone civilization. One need only point to disorders of the liver and the varieties of anemia found in the tropics, to illustrate the lure which the tropics should have for the pathologist and the hematologist.

In general, it may be truly said that the study of disease in tropical environment lifts horizons and broadens concepts of the reaction between the human body and its would-be invaders. The physician trained in the temperate zone will find use for all the knowledge he already has when he goes to the tropics, but he will have to supplement this after he arrives with often painfully acquired experience which he could never have obtained elsewhere. He will realize that tropical medicine is temperate zone medicine, *plus*. Peripheral edema may not be due at all to nephritis, but to vitamin deficiency; pain in the right lower quadrant may be due to malaria, and intestinal obstruction or asthma may be due to ascarid worms. The Samoans suffer from filariasis but they also die of tuberculosis; the natives of Africa have trypanosomiasis, but they also suffer from the same nutritional deficiencies as the patients in Birmingham, Alabama; the peoples of India and China have leishmaniasis and distomiasis (fluke infestation), but they also die of pneumonia and typhoid.

*The Lack of Organized Information on Exotic Diseases.* Tropical medicine as it is known today is a composite of facts gleaned from a multiplicity of diverse and unrelated sources. Such a book as McKinley's on the geography of disease gives some idea of the extent of contradiction and discrepancy in our knowledge. Maps of tropical diseases have to be approached with great caution because a blank may mean either that the disease is not present, or simply that it has not yet been looked for and reported. Yellow fever, which for years contracted and faded to minute proportions on the world map, has suddenly blossomed forth to cover large areas of two continents, simply because a new concept of the disease has been established.

Most of the facts about the health of tropical regions come from governmental reports, usually issued annually by the European powers responsible for the various areas. For large tracts of the earth we are dependent on these reports for vital statistics. It is true that they are often defective, their methods and results are frequently not comparable, and much is hidden in unrelated files. Sometimes there is deliberate lack of candor in revealing conditions. Facts can only be secured by patient digging; yet this is the best source for general knowledge.

Other sources of information are the reports of such quasi-governmental organizations as the Health Office of the League of Nations, the Indian Medical Service, and the observations of our own Army in Panama

and the Philippines, and our Navy in Samoa, the West Indies, and elsewhere. In this connection should be mentioned the many national societies of tropical medicine, and the numerous institutes and research centers in tropical countries, such as the widely scattered Pasteur Institutes, the Malaria Research Institute of India, the Oswaldo Cruz Institute of Brazil, the Gorgas Memorial Institute in Panama, and others. There are famous schools of tropical medicine in tropical countries, such as Puerto Rico, Cuba, Mexico, India, Egypt, and Java, and others in great centers of teaching in temperate zone countries, such as London, Liverpool, Paris, Antwerp, Lisbon, Peiping, Melbourne, Boston, New York, and New Orleans. There was once an important center in Hamburg.

There are also the great private and semiprivate foundations such as the Rockefeller, the Leonard Wood Memorial, and the British Empire Leprosy Relief Association. Various universities have sent expeditions to South America, Africa, and elsewhere for the investigation of particular diseases, and other commissions under Red Cross or military auspices have undertaken the study of typhus fever, relapsing fever, pneumonic plague, and other epidemic diseases.

Big commercial companies, representing among others the oil, rubber, and fruit interests, have stimulated the study of tropical diseases in an enlightened spirit of humanitarianism; important contributions have also been made by physicians maintained in tropical countries by missionary societies. These lone workers, and the private practitioners, both foreign and native, in tropical regions, have gathered a mass of information of great value out of proportion to their numbers because of their long periods of residence and their intimate knowledge of language and people.

This catalogue is obviously incomplete, but suffices to bring into relief the patchwork picture of tropical medicine as it now is, and suggests why this field is still so unorganized and unequally developed.

## The Content of Tropical Medicine

Medicine in general comprises certain conventional subdivisions such as pathology, symptomatology, and therapeutics. Let us assume these standard disciplines and proceed to examine in some detail the special fields which tropical medicine draws within its ambit.

*Helminthology* is concerned with the metazoan parasites which inhabit the intestinal tract or the tissues of man. They include the hookworms, whipworms, pinworms, and ascarids; the filariae of skin and lymph tissue; the cestodes, some of them living as adults in the intestine, and others as immature forms in the tissues; and finally the trematodes, the flukes of lung, liver, intestines, and blood.

*Protozoology* furnishes the next group of parasites, the amoebae, the blood flagellate trypanosomes, the tissue flagellate leishmanias, the spirochetes of treponematosis (yaws, syphilis), leptospirosis, and rat-bite fever, and borreliae of louse- and tick-borne relapsing fevers. This unicellular group also includes the plasmodia of malaria.

*The bacteriology* of tropical medicine introduces the bacillus of plague, the mycobacterium of leprosy, the vibrio of cholera, the rickettsiae of typhus and spotted fever, and the viruses of dengue and yellow fever.

Tropical *mycology* must not be omitted. Perhaps the discovery of penicillin will stimulate interest in this hitherto neglected subject.

*Entomology.* Tropical medicine is intensely concerned with arthropod life, for insects and arachnids furnish the vehicles for transfer of diseases, and the reservoir for their maintenance in nature. Animals of other phyla provide intermediate hosts for the propagation and dissemination of parasites. Thus, importance attaches to the distribution, identification, anatomy, physiology, and ecology of mosquitoes and other flies; the fleas, bugs, lice, and ticks; the snails, crabs, frogs, and fish.

Many of the lower orders of mammals share tropical diseases with man, and constitute reservoir hosts for the infections. Illustrations of this are the carnivorous cats, dogs, and wolves in helminthiasis; the wild game of the veldt in trypanosomiasis; the monkeys, marsupials, and edentates in yellow fever. Study of these reservoir and alternate hosts throws light on human diseases, and thus *mammalogy, verterinary medicine,* and *comparative pathology* become integral parts of

tropical medicine. *Herpetology* and the production of antivenins must also be included at this point.

A fascinating and as yet unwritten chapter of knowledge is the evolutionary history of these parasites and their hosts, and their relation to the great *geological* epochs. Tropical diseases are related to the fact that the oases in the Sahara are the last drying remnants of once broad and flourishing jungle. Tropical medicine is interested in the theory that the "nose" of South America once fitted snugly into the concavity of Western Africa (the so-called Wegener continental flotation hypothesis), and the theory that there was once a continent (Lemuria) connecting up India and Ceylon with Madagascar and Africa. The distribution of tropical diseases and their vectors is certainly related to the fact of Wallace's Line which swings through the East Indies and separates the fauna of Asia from that originating in Australia. Knowles has attempted to explain the present peculiar distribution of quartan malaria on geological grounds, and has advanced the view that *P. malariae* was the first of the plasmodia to select man as host. This is only one tentative furrow in an exceedingly interesting field.

The sciences of *meteorology* and *climatology* are admitted to be of increasing importance in medicine. The formation of clouds and winds, the fluctuations of temperature, the distribution of isobars, the amount of precipitation, all have a direct bearing upon the presence and distribution of disease. Change of temperature is a tonic to the human organism, a blessing which the inhabitants of the energizing regions of the world, such as Europe, the United States, South Africa, and the Argentine, have not fully realized. The absence of temperature-swing in tropic zones has a bearing upon the temperament of tropical peoples, and probably contributes to their relative freedom from the so-called degenerative diseases of civilization, the price which men of the temperate zones must pay for the mixed blessing of aggressive energy.

How far, and at what cost, can the white man be acclimatized to the tropics, are questions still to be settled. That he can live there in comfort is proven by experience in Panama, the Dutch East Indies, and elsewhere. But man has only two means of disposing of the heat generated by combustion within himself; namely, radiation and perspiration. Where environmental temperatures exceed 98.6° F., radiation is no longer possible—indeed is replaced by absorption. The body is therefore restricted to the alternative; but loss of heat by evaporation from the skin surface depends upon the ability to sweat, and this also has obvious limits. Man in the tropics is therefore forced to live at a lower level of energy and of oxygen consumption to keep from dangerous accumulation of internal heat. Paradoxically, as Mills has pointed out, the laborer in the tropics turns out less work per unit of time, but is a more efficient machine than the northern laborer.

*Nutrition.* The science of food elements and requirements finds in the tropics an almost virgin field, a multiplicity of "impressions" and few established facts. In general, the tropical menu is monotonous, and the food not so palatable, so thoroughly cooked, or so finely divided as elsewhere. The appetite craves less of animal foods and more of starches, greens, and fruits, leading to deficiencies in calcium, the B complex, and the animal proteins. Among the minerals, iron is particularly lacking, a fact which leads to various forms of hypochromic anemia.

Rice is the staple food of one half the world's population, and for this portion of the human race it constitutes eighty to ninety percent of the food intake, supplemented in the case of the Arab with dates and locusts, and elsewhere with dried fish and pickled radish. Rice has a good selection of vegetable proteins, but does not furnish all that are necessary for full health, and is deficient in minerals and vitamins.

There is some support for the view that most people in the tropics get less than the optimum intake of the B complex. The B contents of tropically grown foods are definitely lower than those of northern climes, and since B is water-soluble it is lost in the sweat. Further, it has been shown that mice living in a temperature of 90° F. require twice as much B complex per gram of food

as mice living in a temperature of 65° F., and presumably something of this sort is true of man. Since there is close relationship between vitamin B and "resistance to infection," there are grounds for the assumption that natives of the tropics, failing to receive adequate quantities of the complex, are more susceptible to infectious diseases.

In this connection, Cannon has pointed out that food-proteins are essential not only for the formation of normal globulin in the blood, but also for the closely related antibody-globulins. In other words, the ingestion of a full complement of amino acids is essential insofar as antibody production is fundamental to "resistance." Cannon is speaking particularly of the gradual depletion of the body proteins in war and famine, resulting in pestilence in its various forms. But in tropical countries, though the factor of war may be absent, unbalanced diet and chronic famine is a constant specter. Doubtless here also hypoproteinemia results just as inevitably in widespread susceptibility to disease.

Many tropical peoples are slight of build and short of stature. Is this due solely to race, or do climate, nutrition, diet, and other factors also have a role? Krogman quotes Hooton to the effect that height, weight, thoracic dimensions and proportions, and similar bodily features are so directly susceptible to health, diet and food habits, climatic factors, exercise, occupation, and other miscellaneous influences as to render them useless as racial criteria.

*Neuropsychiatry.* Unquestionably, white men and women going to the tropics undergo considerable psychic trauma. McCartney, who has recently reviewed the subject of tropical neuropsychiatry, predicts that many men in the services will return from the tropics with permanent neuropsychiatric disabilities. Strange environment, foreign language and customs, unaccustomed food, intense light and heat, tropical rains, ubiquitous and exasperating insects, all are factors which, combined with the monotony of existence, the lack of amusements, and restrictions of companionship, lead to neuroses and depressions. Least successful are the egocentric and rigid personalities lacking poise or given to idiosyncrasies and complexes. Most successful are the sanguine, the adaptable and resourceful, and the intellectually curious.

Men and women who have gone to the tropics under the compulsion of commercial, religious, and humanitarian incentives are often able to establish homes which cushion them from the warping impact of the foreign environment. Some, however, fail to adjust, and are invalided home as "nervous breakdowns" or misfits.

Men in the armed services at tropical stations have the advantage of knowing that their period of service will probably be short; they have many companions of their own kind with food and other things from home; their life may be uncomfortable and often dangerous, with few opportunities for amusement and recreation, but it is seldom monotonous for long. But in contrast to these stabilizing factors is the frustrated feeling—often unexpressed—that they are not there by their own will, but in the control of forces which they are unable to influence. There are many in the service ranks of low emotional adaptive power, and in the presence of danger and the natural human reaction of physical fear, it is not surprising that psychiatric casualties are proving to be an important feature of tropical campaigns.

Turning now to other fields in which tropical medicine has an interest, we come to *ethnology* and *anthropology*. Many of the advances in both these sciences have been made by physicians working among the natives of tropical regions. Customs, religious rites, and social organizations have a bearing on health. In Moslem countries the necessity for ablutions leads to pollution of the river banks, and the pilgrimages to Mecca tend to spread disease. In India the great fairs and festivals, the veneration of the cow, and the respect for insect life create problems in the control of disease. In many countries patriarchal and tribal organizations make enforcement of health laws difficult. The importation and traffic in slaves have always been a feature of the spread of disease in tropical countries. It is of particular interest in connection with the export of slaves from Africa through Abyssinia to

Arabia and the East, and the importation of black slaves and their diseases into the New World.

No one will deny that tropical medicine has a vital interest also in the development of the *economic* and *political* life of the tropics, not only for the acclimatization of the white man, but in the inevitable future industrialization of wide regions still undeveloped. The resources of large areas have only been touched. There is, for example, more water power in the single basin of the Congo than is harnessed at present in the *whole* of the United States. Political organizations, such as colonies, mandates, international trustees or hitherto untried devices for native development, must be buttressed by health schemes of a magnitude as yet not attempted. Whole diseases must be eradicated, and effective barriers erected to prevent the spread of diseases to new regions of the earth along lines of travel and commerce. Imaginative planning will have to be done in terms, not of nations, but of continents and the globe.

This discussion has presented two challenging facts, namely, that tropical medicine is a rapidly expanding field, and that few of the sciences can afford to refrain from interest and participation in this expansion. If the medical world has the wit to draw on all these ancillary sciences, and if these sciences have the wisdom to see what opportunities for them lie in the matrix of tropical medicine, new and exciting vistas will open both for the advancement of abstract knowledge and for the improvement of man's health, as dividends accumulate from this cooperative activity in the tropics.

## MALARIA CONTROL

WAR correspondents have reported that the Battle of Bataan was lost, not because the ammunition was gone, but because the quinine tablets gave out. Ten days before the end, 80 percent of the front-line troops were suffering from malaria. When the Japanese extended their advance to the south, America lost both her rubber and her quinine. Fortunately as far as quinine was concerned, synthetic chemistry jumped into the breach, but with the war extending into malaria-infested countries all over the world there is still great need for a drug that is better than quinine or any available quinine substitute. Indeed among war diseases malaria ranks ahead of typhus and influenza in the list of unresolved problems.

Over many years, and in many countries, The Rockefeller Foundation has worked in the field of malaria. During the earlier period its activities were largely confined to various methods of mosquito control, such as drainage, screening, the use of fish to destroy mosquito larvae and the employment of sprays and Paris green. But in many parts of the world these measures are inapplicable for economic or physical reasons. In such areas the widespread use of drugs is at present, and particularly under war conditions, the only feasible means of control.

The use of drugs, however, has been shown to be largely ineffective, even under the most favorable circumstances, because of two fundamental disadvantages inherent in the drugs now in use. In the first place, these drugs do not always eradicate the infection, and thus a constantly increasing carrier reservoir accumulates, tending to spread the disease. In the second place, the drugs cannot be wholly relied upon to prevent the development of malaria following the bite of an infected mosquito.

These disadvantages assume even greater importance in wartime than under normal conditions, because the introduction of large numbers of nonimmune persons into malaria-ridden countries naturally increases the incidence of the disease. The development of some new drug, not subject to the limitations of quinine and its substitute, would have enormous military and public health significance. . . .

The [Foundation] campaign in Brazil . . . was successful in driving out a particularly dangerous malaria mosquito imported from Africa and called *Anopheles gambiae*. It is a pleasure to report that there was no reappearance of gambiae in 1942 in the area in which the campaign was waged. But although the gambiae is driven out of America, this is not the end of the story. There remains its homeland. The bad reputation of Africa as the Dark Continent is based in part upon the exceptional activity of this mosquito. . . . The gambiae holds firmly in its grasp whole areas, from Dakar in the west, straight across the Continent, and all the way south. Unless this mosquito can be exterminated, or its effects neutralized, it does not seem probable that the vast regions which it now contaminates can be successfully developed.—*Raymond B. Fosdick, in "The Rockefeller Foundation-Review of Work in 1942."*

# NEWTONIAN AND OTHER FORMS OF GRAVITATIONAL THEORY*

## I. NEWTONIAN THEORY

By GEORGE D. BIRKHOFF

IT has been generally granted that Sir Isaac Newton's work on universal gravitation constitutes an unsurpassed scientific achievement. To begin with, in order to develop his ideas concerning the nature of gravitation, Newton devised that necessary mathematical instrument of modern scientific thought, his "fluxions," now termed the calculus; then, with the aid of this powerful new tool, he developed the principal theoretic consequences of his inverse square law; furthermore, he applied his theory to the most varied types of gravitational phenomena with extraordinary skill and penetration; and, finally, after making certain that supposed observational discrepancies were disposed of, and after transferring his analytical equations into the language of infinitesimal geometry current in his day, he gave out his great master work, the *Principia* of 1687. Truly this four-fold accomplishment was most remarkable; and the unfoldment of the program for the physical sciences which Newton thus initiated has continued to dominate the field of physics during nearly all of the two and a half centuries which have since elapsed:

> Nature and Nature's laws lay hid in night.
> God said "Let Newton be," and all was light.

In this tercentenary year (1942) of Newton's birth it is therefore natural and appropriate to estimate his theory of gravitation in its relation to the new forms of gravitational theory which have developed in the last four decades. This I shall endeavor to do in what follows, avoiding the use of technical mathematical terms except in a purely descriptive way. Likewise when simple equations are written down in a few cases, it is only to show the obviously close formal analogy between the Newtonian theory and its modern counterparts.

It should be remarked first of all that not until after the celebrated Michelson-Morley experiments of 1887 did it begin to be realized that matter was astonishingly indifferent to motion through the ether. Between Newton's discovery and these experiments there had elapsed more than two hundred years. In this period physicists and astronomers did little more than consider the following questions concerning gravitation: Is it not possible that gravitation travels with a finite velocity instead of with infinite velocity as demanded by Newton's theory? Is it not possible that an exponent slightly different from the exponent 2, appearing in his law, might improve the theory? Are or are not "inertial" mass and "gravitational" mass exactly the same, as was postulated by Newton? The careful study of these three questions had only served to confirm the Newtonian theory.

Aside from this specific work, one fact, however, had emerged: A very close examination of the phenomena of the solar system by theoretical astronomers, on the basis of the Newtonian law, had shown that there was a slight but definite excess of perihelial advance of the planet Mercury amounting to 41″ per century. Since the velocity of Mercury is large as compared with the velocities of the other planets, it was natural to conjecture that here was beginning to appear a deviation from the Newtonian law which should become more and more marked as the velocity approached that of light, which is the fundamental limiting velocity in an electromagnetic universe.

The analysis here undertaken will begin with some simple mathematical observations and then pass on to give an outline of the Newtonian theory (part I) and of recent

* From the symposium on "Natural Philosophy" commemorating the 300th anniversary of Newton's birth which was to have been presented at the New York meeting of the American Association for the Advancement of Science.

relativistic theories of gravitation (part II). My approach will in no sense be historical.[1] Instead, it will present a comparative analysis of the various forms of gravitational theory. The Newtonian theory of gravitation may be likened to the opening movement of a great scientific symphony, expressed in the natural language of everyday geometrical and temporal intuition, namely that of 3-vectors. There follows an analogous second movement formulated in the terminology of 4-vectors, appropriate to 4-dimensional "astro-electric" space-time. In this, Nordström's gravitational theory of 1912 appears as the natural development, although ending in an unresolved discord because certain slight gravitational phenomena, like that observed in the motion of Mercury, are not accounted for. Then there follows immediately the very brilliant, chaotic, and incomplete third movement formed by the gravitational theory of Einstein of 1916. Here the calculus of tensors, appropriate to space-time curved by matter, is employed throughout. In this way the discord in the second movement is resolved and the predictive power of the new theory is established.

Now it has been generally agreed that (to carry our musical comparison a step further) there is need for an appropriate coda. Weyl, Kaluza and others have shown that there exist interesting possibilities in the way of providing a unified account of electromagnetic and gravitational phenomena. To these I shall refer only briefly. But I shall characterize more in detail a recent attempt of a fundamentally different type, which I presented at the Astrophysical Congress which met at Puebla and Tonantzintla, Mexico, in February, 1942.[2] My theory, like that of Nordström, is based on the simpler Lorentz-Minkowski space-time of electromagnetism.

It is entirely too early to say as yet how any of these various theories will be regarded in the future. One may well doubt whether any known physical theories will have final validity for the comprehension of Nature. We can be quite certain, however, that the classical Newtonian theory of gravitation will always remain serviceable to the theoretical astronomer. Indeed, from this point of view, a more complicated gravitational theory, like that based on a curved space-time, can only operate as an "auxiliary construct" (to use Larmor's characterization), taking into account a few minute relativistic gravitational effects almost beyond the reach of observation.

Of course, it is impossible to understand and appreciate adequately the magnificent work of Newton without proper historical perspective. It is easy but misleading to magnify his position at the expense of his contemporaries and predecessors. Perhaps the half dozen figures of greatest import in the Newtonian background are those of Archimedes, Galileo, Kepler, and Descartes among his predecessors, and, among contemporaries, his illustrious friend, the "Summus Hugenius," and his yet greater rival, the mathematician and philosopher Leibniz. Furthermore it must be admitted that both the calculus and the classic theory of gravitation lay quite near at hand when Newton found them. This is evidenced by the fact that Leibniz was a co-inventor of the calculus, and by the prevalent discussion of a possible force of attraction inversely proportional to the square of the distance.

Our point of view will be mathematical rather than physical, in the following sense. The physicist as such disclaims interest in any theory which is not in accord with Nature, even though it has achieved a considerable degree of success. At each moment he is hoping to discover the ultimate, all-embracing theory, after which he expects to abandon forthwith the earlier partial explanations. On the other hand, the mathematician studies freely all forms of theory which possess a certain esthetic-mathematical quality. Thus he is not only interested in ordinary real numbers, but invents imaginary numbers and a host of other types of number which interest and fascinate him as objects of abstract thought. Often he finds later on that these generalizations and modifications turn out to be essential for the understanding of natural law. Thus, to take

[1] For an extremely interesting historical and scientific evaluation of Newton see E. T. Bell, "Newton After Three Centuries," *American Mathematical Monthly*, November, 1942.

[2] To be published in the Proceedings of the Congress.

a recent striking example, in quantum mechanics it has been necessary to deal with "matrices," which constitute a kind of generalized number previously studied in detail by mathematicians for their own sake. Likewise mathematicians have studied many forms of geometry, and in particular the general $n$-dimensional Riemannian geometry of curved spaces; and only by use of this theory and the associated mathematical theory of tensors of Ricci and Levi-Civita was it possible to develop the consequences of the "equivalence hypothesis" which lies at the basis of the generalized theory of gravitation of Einstein.

In what follows, then, the esthetic-mathematical point of view will be taken throughout. Moreover, we shall not venture to conjecture what the ultimate account of gravitation is going to be, but rather we shall try to coordinate and appreciate the formal structures of various gravitational theories, as well as to assess their serviceability in physics.

*The Use of Models in Mathematics and Physics.* From the beginning of his scientific thinking, man has progressed by means of conceptual models taken from Nature. In fact, from a certain point of view, mathematics itself, crudely defined as the study of number and form, takes its origin in this characteristic way. For, the simplest type of physical universe is one thought of as made up of classes of distinguishable objects, considered without regard to their specific properties but only as comparable with one another by the process of matching or one-to-one correspondence, as when the fingers of one hand are matched with those of the other. Through experience with this simple universe of classes, the concepts of logic and number arise irresistibly. Likewise the type of idealized universe in which there are rigid bodies comparable with one another by direct superposition leads us inevitably to the concepts of Euclidean geometry.

In both of these simple conceptual models so fundamental for mathematics, the complementary processes of Analysis and Synthesis, which Newton insisted were necessary for mathematics and physics alike, are obviously present. The intimate intermixture of these two types of processes in his daily experience with number and form has led man to assign to these ideas an absolute and eternal validity not readily granted to other conceptual ideas. Although we no longer think of Euclidean geometry as incorporated exactly in real space, nevertheless Logic, Number, and Geometry are firmly established as basic theoretical constructs of the human mind.

The point of view will be taken in the present paper that conceptual models are likely to continue to play a fundamental role in the development of theoretical physics, despite the apparent abandonment of such models in recent quantum-mechanical advances. All of the gravitational theories to be considered here rest upon the basic model of an underlying space-time continuum of four dimensions, whose "points" correspond to events.

*The Role of Postulates.* It was because the Newtonian Law of Gravitation was so deeply consonant with the simple intuitive ideas of space and time, as well as with all the known physical facts of his day, that Newton was able to affirm *"Et hypotheses non fingo"*—I do not frame hypotheses! Leibniz had a similar feeling. Said Leibniz, "Far from approving the acceptance of doubtful principles, I would have people seek even the demonstrations of the axioms of Euclid."

From the more sophisticated logical point of view of the present day, it would be considered, however, that all physical and mathematical theories are necessarily built upon certain hypotheses, or "postulates," which need to be carefully stated. In Newton's *Principia* his celebrated gravitational hypothesis is introduced through an analysis of known physical facts, in particular of the consequences of Kepler's planetary laws of elliptic motion. We may synopsize the set of postulates which Newton tacitly employed by saying that he accepted the workaday conceptual ideas of Absolute (Euclidean) Space and Absolute Time, although he saw no reason to distinguish between the Absolute Space and any other space in uniform translatory motion with respect to it, nor to fix upon theoretic units of space or time.

This means for us today that all of Newton's concepts were such as to be best expressed in the mathematical language of 3-vectors (that is, vectors with three com-

ponents). For example, a velocity $u$ is a directed quantity of this vectorial type, since to determine it we need only specify a directed line or vector, showing the direction and magnitude of the velocity in ordinary three-dimensional space.

In what follows we shall see how the Nordström theory referred to above is highly analogous to the Newtonian theory, except that the language has been changed to that of 4-vectors. Furthermore, we shall find likewise that the generalized theory of Einstein is highly similar in structure. Here the appropriate language is that of tensors.

*Groups, Invariants, and Mathematical Language.* For the deeper understanding of all these theories, it is necessary to say something about the mathematical concept of a "group of operations." If any two or more of the operations can be combined into a single resultant operation of the same type, and if there always exists an operation of the set which undoes what another operation does, then the collection of operations is said to form a "group." It is furthermore found to be convenient to regard the operation which does nothing, called the "identity" operation, as an element I of the group. Thus the postulates for such a group are essentially the following in concise form:

I. $(AB)C = A(BC)$ for any $A$, $B$, $C$,
II. $AI = IA = A$ for any $A$,
III. $AX = B$ has a unique solution $X$ for any $A$, $B$.

The table showing the result of combining any two of these operations constitutes the so-called "multiplication table" of the group.

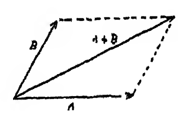
For example, if we consider a square lying on a table and the operations of rotating the square into itself upon the table, we find that there are four operations: the identity $I$; a rotation through 90°, $A$; a rotation through 180°, $B$; and a rotation through 270°, $C$. The corresponding multiplication table is obviously the following:

| | $I$ | $A$ | $B$ | $C$ |
|---|---|---|---|---|
| $I$ | $I$ | $A$ | $B$ | $C$ |
| $A$ | $A$ | $B$ | $C$ | $I$ |
| $B$ | $B$ | $C$ | $I$ | $A$ |
| $C$ | $C$ | $I$ | $A$ | $B$ |

Another very elementary example is furnished by the operations of adding an integer (to a number). Here the identity operation $I$ is that of adding zero.

Now in the geometric background of Euclidean space, the group of rigid motions has always entered intuitively. It will be recalled that Euclid accepted the proof of geometric theorems by the method of direct superposition. This really meant that he was accepting the group of motions as valid in elementary geometry. The natural analytic language in which such geometric ideas are appropriately couched is that of 3-vectors already referred to above.

In this mathematical symbolism certain simple processes turn out to be fundamental. The simplest of these is the multiplication of a vector by a constant which changes the magnitude of the vector by this factor without modifying its direction. Another simple process is that of vector addition portrayed in the following figure. Still another impor-




tant idea is that of the "scalar product" of two vectors; if these vectors are $f$ and $g$, this would be indicated by $f \cdot g$. A "scalar" quantity is one, like that of mass, which is essentially a magnitude without direction. The simplest types of quantities in vector theory are vectors and scalars. More complicated but fundamental types are those termed bivectors, dyadics, triadics, etc., by Gibbs. The simplest vector operations, involving the calculus, are indicated by div (read divergence), grad (read gradient) and curl. We shall not endeavor here to define these basic operations.

Two extremely important related concepts in the theory of groups are those of invariable properties and of invariants. In the illustration above of the group of rotations taking a square into itself, an invariable property is that of the adjacency or oppositeness of sides and vertices: evidently adjacency and oppositeness are qualities not affected by performing any operation of the group. Similarly, in the case of the additive

group of integers, the difference of two numbers, $x-y$, expresses an invariant in the technical sense, because this difference is not affected by adding the same integer to both $x$ and $y$.

In the case of the group of motions of Euclidean geometry, the most fundamental variant is the distance between two points, which is not affected by any motion whatsoever. Riemann showed how this concept of distance appropriately extended lay at the foundation of $n$-dimensional geometry, whether flat or curved. A somewhat less fundamental concept, but still having great importance, is that of the angle between two lines or vectors. It may be shown that in general the invariants of any group determine the group completely.

Newton really accepts, as the underlying group in his physical theories, this group of rigid motions augmented by uniform translatory motions in time. This imposes a tacit esthetic requirement upon the whole Newtonian development.

The simplest illustration of the expression of a Newtonian law in vector terms is that conveyed in the familiar statement that the resultant of two forces acting upon a point is the vector sum of the two constituent forces.

It is also true that in the later gravitational theories there exists a specific underlying group which to a large extent predetermines the form which the theory may take. It is for this reason that the comparative study of gravitational theories is possible.

*On Mathematical Consistency.* Physicists have never worried much about the question of mathematical consistency. For example, in the heyday of classical physics, solids were thought of as having a possible type called the perfect elastic solid. The articles and treatises concerned with such elastic bodies never considered the fact that the mathematical theory itself would fail under certain conditions. Thus, suppose that two perfectly elastic spheres were to collide with one another along their line of centers with a relative velocity greater than twice that of the disturbance velocity (that is, the "velocity of sound") in the medium. Then it is true that the basic differential equations of motion themselves become completely useless and the theory of elasticity breaks down. But this fact was hardly mentioned as of any interest whatsoever. The whole history of physics up to the present day shows a disregard of this question of mathematical consistency.

Now it is characteristic of the mathematical point of view here advanced that such inner consistency is held to be a *sine qua non* in a successful theory. In what follows I shall keep this requirement in the foreground, although doing so introduces considerations which most theoretical physicists would consider as of little importance.

*Mysticism in Physical and Mathematical Thought.* The developments of the last fifty years in mathematics and physics have involved in ever-increasing measure semi-mystical considerations growing out of a highly developed sensitivity as to the role of formalism. It is well to say something about these matters before taking up the consideration of Newtonian and other gravitational theories.

From Newton onwards, theorists in the field of physical thought have tended towards opinions of an intuitive type which constitute an essential directive element in their creative work. In fact, it seems to be true that long-continued and intensive study in any scientific field always leads to vague ideas which are felt to be of basic importance for deeper understanding. The concept of energy was initially of this type. Many other instances might be given.

An important mystical idea of this kind was that the laws of nature can always be formulated by means of some "Variational Principle" or "Principle of Least Action." For example, it was found that a ray of light passing through a medium with variable index of refraction follows the path of least length in time in going from a point $A$ to a point $B$ of the body. To an astonishing degree it was discovered that dynamics and classical electrodynamics admit of very condensed mathematical expression by means of an appropriate variational principle. Even today the physical theorist likes to show that a new theory can be expressed in variational form.

As a mathematician I would like to point out that the significance of such a principle is not what it is often taken to be, for the fol-

lowing reasons: In formulating a mathematical problem there is always a large degree of freedom of choice, both in choosing the independent and the dependent variables. There are likewise a great variety of ways of combining a system of equations into equivalent systems. Because of these facts, it is not surprising that one can manage to obtain a variational principle appropriate to almost any physical or mathematical theory. It is certain at least that theories formally reversible in time, such as gravitational theories, will yield to expression in this variational form.[3] Thus variational methods need to be carefully scrutinized.

Another important principle which has been effectively used by the physicist is the Principle of Sufficient Reason, which lies at the center of Leibniz's philosophical speculations. As I have tried to show elsewhere,[4] this principle is closely related to the theory of groups, and its significance may be conveyed in the following symbolic diagram:

| | Principle of | | Theory of |
|---|---|---|---|
| Metaphysics ⟷ | Sufficient | ⟷ | Ambiguity. |
| | Reason | | Groups |

Perhaps one elementary but typical illustration of the use of this Leibnizian principle in physics may be mentioned. Suppose that two equal forces act upon a point. Because of the ambiguity associated with the relevant group of motions, it is clear that the resultant force must not only lie in the plane of the lines of the two forces but necessarily falls along the bisector of the angle which they form.

It is such principles as the Principle of Least Action and the Principle of Sufficient Reason which have led many of the foremost physicists to adopt a somewhat mystical attitude toward the physical universe. There is no doubt that a large part of speculative physics up to the latest period can be conveniently interpreted in terms of these principles. If we conjecture with Plato that the Deity continually geometrizes, it seems almost certain that the language of Deity will involve the theory of groups and the corresponding Principle of Sufficient Reason on the one hand, and Variational Principles on the other!

An extreme but characteristic expression of the mystical attitude towards physical thought, and of confidence in the unlimited power of the mathematical symbol, is that of Eddington when he says in his *Relativity Theory of Protons and Electrons* (1936):

> Unless the structure of the nucleus has a surprise in store for us, the conclusion seems plain—there is nothing in the whole system of laws of physics that can not be deduced unambiguously from epistemological considerations. An intelligence, unacquainted with our universe but acquainted with the system of thought by which the human mind interprets to itself the content of its sensory experience, should be able to attain all the knowledge of physics that we have attained by experiment. . . . For example, he would infer the existence and properties of radium, but not the dimensions of the earth.

Perhaps such ideas, which are held by nearly all physicists in one form or another, merely indicate a belief that all physical theories are ultimately expressible in simple unitary mathematical terms.

In what follows an endeavor will be made to state certain vague ideas concerning the differing gravitational theories, which are important for their philosophic evaluation.

*The Framework Based on the Rigid Body and Ordinary Time.* The Newtonian theory starts out with the framework of space and time suggested by daily physical experience. All about us there are rigid bodies which need to be compared and measured. In this way we arrive at the concepts of geometry, and of a space at first attached to the earth, and later on attached to the fixed stars.

Likewise, the notion of time as measured by clocks becomes more and more definitely established on an intuitive basis. Events are thought of as happening when seen, so that the concept of absolute simultaneity is firmly established.

These ideas of space and of time are embodied in the concepts of Euclidean space and of ordinary time. In this space the point of reference, the direction of the axes of reference, and the specific units of distance play no essential part; and likewise, the choice of the instant of time, called the epoch, from which time is measured and of the unit of time has no special importance. Furthermore, as was noted previously, there is an

[3] See my *Dynamical Systems* (New York, 1927), in particular Chapter IV.

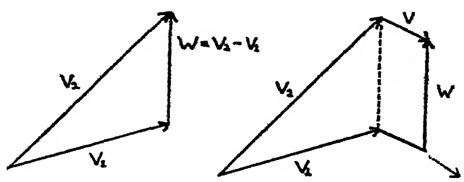
[4] *The Principle of Sufficient Reason*, The Rice Institute Pamphlet, Jan., 1941, pp. 24–50.

additional degree of relativity in that any system moving at uniform velocity of translation with respect to the system of reference is regarded as a valid reference system.

*The Underlying Group and its Two Invariants.* There would be no object in specifying here in symbolic form exactly what the corresponding group is; it suffices merely to say that if we have given any one set of space coordinates $x$, $y$, $z$, and time coordinate $t$, there is a large variety of other sets of space coordinates $x_1$, $y_1$, $z_1$ and time coordinate $t_1$ which are equivalent in a physical sense to the given system of coordinates, namely the sets attached to other systems relatively at rest or in uniform translatory motion.

The fundamental invariants of this Newtonian group are two in number: the distance between two points at the same time; and the interval of time between two events. In fact, the Newtonian group is precisely the most general group which leaves these two quantities invariant.

*The Corresponding Language of 3-Vectors.* As has been noted before, the language of 3-vectors is that which is appropriate to this type of group, but there are certain restrictions of which at least one should be noted: To say that two vectors are equal is evidently an invariantive statement, since if two vectors are equal in any one coordinate system, they will be equal with reference to any other system whether relatively at rest or in uniform translatory motion. On the other hand, the vector velocity has no invariantive characteristics, since the vectors with respect to one system may not be the same as with reference to another system. This circumstance explains why it is that velocities never appear directly in the Newtonian mechanical and gravitational theories. However, the difference of two velocities is invariant in character, as may be seen from the following figure.




Here the difference of two vectors $v_1$ and $v_2$, is indicated, first, with respect to the given system of reference and, secondly, with respect to a moving system impressed with an additional velocity $v$. It is seen that the final difference $w$ is the same in both cases. Now the concept of acceleration is essentially one involving differences of velocities, and thus is explained the extraordinary importance of the concept of acceleration and its nearly equivalent concept of force in the dynamical theories of Newton.

More explicitly, the force exerted on a body is measured by the product of its mass and its (vector) acceleration, that is, by $M\ du/dt$ where $M$ is a scalar invariant called the mass and $du/dt$ is the notation of the calculus for the (vector) rate of change of the vector velocity $u$ along the path of the mass in question.

*The Particle Model of Newtonian Gravitation.* Imagine now a system of any number of mass particles in otherwise empty space. For simplicity, we may consider first the case of only two particles of given masses $m_1$ and $m_2$.

The Newtonian law states that the force which either mass exerts on the other acts along the line joining the two particles and is inversely proportional to the square of the distance between them; in *absolute* gravitational units of mass the force is precisely equal to the product of the masses divided by the square of the distance. We always employ such absolute units in what follows.

It is evident that this formulation is in accord with the underlying Newtonian group and is as simple a formulation as can be conceived if the force is to tend to disappear as the distance between the two particles increases indefinitely. It is true that it is natural to consider the exponent 1 as well as 2. But the analysis by Newton of the known Keplerian laws of motion in two body motion showed that the exponent must be 2.

When more than two particles are present the resultant force on any one of them is simply taken as the vector sum of the forces of attraction of all the other mass particles.

This idealized model of the solar system has explained practically completely the facts of observational astronomy and predicts correctly the future motion of heavenly bodies to a remarkable extent. Laplace and

other eminent later astronomers have verified the Newtonian theory in more and more detail.

*The "Cosmic Dust" Model.* In order to explain gravitationally the flattening of the earth at the poles, tidal motion, etc., it is necessary to extend the particle model so as to embrace rigid, elastic, and fluid bodies. Newton began this process of extension by proving that homogeneous rigid spheres would attract one another according to his theory exactly as though their masses were concentrated at their centers. By proving this basic theorem, he was able to reduce this model to that of the simpler particle model. There is no theoretic difficulty in applying the Newtonian theory to any given type of matter, since, according to Newton's law, the known gravitational forces are merely superimposed on the other forces.

Unfortunately, the rigid body model is absolutely out of place in a relativistic theory of gravitation. A simpler type of model which is serviceable in other cases, however, is that of inchoate matter formed by cosmic dust. The state of such cosmic dust is thought of as characterized by its density and vector velocity at each point, each of the particles being attracted towards all the other particles in accordance with the Newtonian law. This model is especially convenient since it enables one to compare directly the recent relativistic gravitational theories with that of Newton.

With this cosmic dust model we have only to state the following two requirements of Newtonian gravitation in mathematical form, using the appropriate language of 3-vectors: mass is conserved; the acceleration of each point is in accordance with the limiting form of gravitational law obtained by passing from the case of many small particles to the limiting case of a continuous distribution of matter. These turn out to be fully expressible in the following abbreviated form:

$$\boxed{\begin{gathered}\frac{\partial \rho}{\partial t} + \operatorname{div} \rho u = 0, \\ \frac{d(\rho u)}{dt} = \rho \operatorname{grad} g, \\ \operatorname{div} \operatorname{grad} g = -4\pi\rho.\end{gathered}}$$

Here $\rho$ designates the density, $u$ stands for the vector velocity, and $\pi$ is the familiar ratio of the circumference of a circle to its diameter. The last written equation is called Poisson's equation, and the function $g$ which enters is called the gravitational potential and is required to be zero at infinity.

These equations are written down because they serve to show how the appropriate language of the calculus and of 3-vectors yields the essence of a grandiose and extensive theory in extraordinarily abbreviated symbolic form. It will be especially instructive as we proceed to compare visually this symbolic form with the related symbolic forms of the other theories of gravitation.

*Physical, Philosophical, and Mathematical Difficulties.* Despite the tremendous successes scored by the Newtonian theory, there are certain inherent difficulties which remain to be mentioned.

Firstly, as noted above, there are delicate gravitational effects, just within observational range, which the Newtonian law of gravitation does not account for.

Secondly, certain natural philosophical requirements are violated by the theory. For example, this law assumes that gravitational forces are transmitted instantly, whereas elsewhere in nature it appears that interaction between distant bodies is always propagated with finite velocity across the intervening space. Newton himself was aware of this grave difficulty of his theory.

Furthermore, gravitational forces are declared to be merely superadded to the other natural forces. Thus gravitation appears as a kind of afterthought on the part of the Creator!

Moreover, according to this theory, there might be a single rotating body. From the philosophical point of view, however, it appears unreasonable to think that, if there were only a single body in the universe, it could be rotating. For with respect to what would it rotate? Nevertheless, according to Newtonian theory this could be the case.

In what follows we shall merely mention similar general philosophical comments. The following fact should always be borne in mind in this connection: *There are many plausible philosophical demands, and yet no*

*conceivable theory can satisfy them all since they are often mutually contradictory.*

Thus, for example, it is natural, on the one hand, to suppose that matter somehow conditions space. But it also appears almost inevitable to think of events as transpiring in an invariable framework of space and time.

Under these circumstances it is wise to preserve a certain humility of spirit and not to insist too much upon specific philosophic requirements!

There are also some mathematical difficulties in the Newtonian theory, in particular as applied to the "particle" or the "cosmic dust" model.

In the case of the model based on particles, the difficulty arises at collision. As long as only two of the mass points collide, it is possible to determine mathematically the subsequent development of the system in a unique and natural manner. However, it appears that when three or more particles collide simultaneously, there is a mathematical indeterminateness in the subsequent motion. Such indeterminateness seems objectionable in a physical theory based on the concept of causation. From this point of view the particle model has an unquestionable defect.

Likewise the model based on the type of matter called cosmic dust presents its own special difficulties. In fact a dust cloud will from time to time overlap itself, when different parts interpenetrate; this would not take place if there existed elastic pressure. Even worse, a three-dimensional cloud of dust may be turned inside out as time elapses: Suppose that in a spherical cloud all of the points are moving towards the center with a velocity proportional to the distance from the center. The cloud would then condense to a point at a certain instant and continue as an expanding spherical cloud, but "inside out."

If, however, we introduce a homogeneous adiabatic fluid or gas, with a pressure $p$ and density $\rho$ which are functionally related as in a perfect gas, there will still exist a similar possibility of indeterminateness, namely when two portions collide at a relative velocity more than twice the disturbance velocity.

There is, however, an artificial kind of mass particle which avoids these difficulties. If we suppose that the force of interaction between two particles is one of mutual repulsion at small distances, then collision may be impossible. This would happen if, for example, besides the Newtonian force of attraction proportional to the inverse square of the distance, there were a further force of repulsion proportional to the inverse cube of the distance.

Unfortunately, with this type of model, instead of the excessive perihelial advance which is found in the case of Mercury there would be a regression. Furthermore the modified theory would be definitely less elegant than that of Newton, since the particles would no longer be characterized physically by their mass alone.

*(To be concluded)*

# THE AFRICAN ORIGINS OF THE AMERICAN NEGRO AND HIS ETHNIC COMPOSITION

By M. F. ASHLEY MONTAGU

It is the purpose of this paper to analyze and evaluate the available published material which relates to the African origins of the American Negro and his ethnic composition. While this is the principal purpose of the present contribution, some endeavor will be made, in the light of this material, to predict some of the possible trends which the ethnic composition and genetic development of the Negro population in the United States are likely to follow. Our first task will be to determine what is at present known concerning the origins of those Negroes who were brought to America from Africa. Our second task will be to determine the kind and the degree of the ethnic intermixture which the American Negro has undergone since his arrival upon these shores.

## Popular Beliefs

It is a common belief that the American Negro represents a mixed population which was drawn from practically every part of Africa. Du Bois, for example, pointing out that the slave trade must have cost Africa in the vicinity of 100,000,000 souls, adds that "Such a large number of slaves could be supplied only by organized slave raiding in every corner of Africa." He goes on to make the comment, "The natural desire to avoid a painful subject has led historians to gloss over the details of the slave trade and leave the impression that it was a local west-coast phenomenon and confined to a few years. It was, on the contrary, continent wide and centuries long and an economic, social, and political catastrophe probably unparalleled in human history." In a more recent work a very similar viewpoint is expressed, namely, in Edwin R. Embree's *Brown America* (New York, 1933). The author writes:

> The slaves were by no means of uniform lineage. They represented tribes as divergent as the several peoples of Europe. They were captured from provinces covering large parts of Central and Western Africa: Guinea, the Ivory, Slave and Gold Coasts, a great part of what is now French West Africa, the vast stretches of the Niger Valley, the Cameroons, the Congo, and Benguela. Among them were Arabs and Moors from the northerly coasts, the small yellow Hottentots from the South, and Bantu tribes from the equatorial regions, although most of them were the large-bodied blacks from the huge area called Guinea. For four centuries the great commerce in slaves ranged over four thousand miles of African coast, from the Senegal River on the north to the southern limits of Angola, and reached up a thousand miles or more inland.
>
> The early manuscripts record the greatest diversity in the African peoples dealt with. . . ."

While there may be some truth in claiming such a universal provenience for the African origins of the American Negro, the evidence at present existing by no means justifies such blanket claims. Far from being even partially solved, the African origins of the American Negro constitutes one of the most glaring of the unsolved problems relating to his history. The present writer has little doubt that, when the subject receives the attention it deserves, a claim such as that made by Embree will be found to be substantially justified, but until the evidence has been made available and critically examined, it were unwise to grant such a claim any status other than that which it deserves, namely, that of a reasonable supposition rather than a demonstrated fact.

## Historical Introduction

Since the history of Negro slavery prior to the discovery of the New World is of some relevance for an understanding of the factors relating to the introduction of the Negro into America after its discovery, a brief account of that subject may be given here.

Slavery as an institution in Africa itself appears to have been established long before the dawn of written history. The practice of intertribal raiding for slaves, and the trade in them, is a very old African institution. We know that the Egyptians, from the first to the last Dynasties, utilized Negro slave labor, and the facts all indicate that the

Egyptians themselves secured slaves by warfare and raiding, and at other times obtained them by trade. It is quite clear that Cyrene and Carthage supplied Egypt with a continuous stream of slaves from Africa. It was only with the increase in the Fellahin class and the consequent supply of cheap labor that the amount of slave labor employed in Ptolemaic Egypt greatly declined. In Crete, Greece, and Rome, Negroes were enrolled in the army and were enslaved as domestic servants.

The modern trade in slaves actually had its inception in the Mohammedan conquests in Africa in the seventh century of our era; but it was not very much earlier, if at all, than the twelfth century that Negro slaves were expatriated from the continent of Africa. During the conquest of Spain and Portugal the Moors, from 1195 onwards, brought with them many Negro slaves. Indeed, it appears to have been the Moors who familiarized the Spaniards and the Portuguese with the institution of slavery. Except for the fact that some Negroes appear to have been brought from Africa by some Spanish adventurers during the latter part of the fourteenth century, definite evidence of the arrival in Europe of Negroes as slaves from Africa is not available until the year 1442, when Antem Gonsalvez, a Portuguese sailor, took back with him to Lisbon ten Negroes who had been seized at Rio de Oro on the northwestern coast of Africa. It is by some stated that these Negroes were presented by Prince Henry to the Pope, while others state that they were sold at Lisbon, with the result that numbers of Gonsalvez's fellow-countrymen fitted out expeditions which, in the course of the succeeding fifty years, brought many slaves to the Hispanic peninsula.

The historical and documentary evidence shows that a large number of expeditions for the purpose of securing slaves were made during this period. By the year 1474 in the Spanish city of Seville the slaves were so numerous that Ferdinand and Isabella nominated a celebrated Negro, Juan de Valladolid, as Mayoral of Negroes in that city.

With the accession of John to the throne of Portugal in 1481 the traffic in African slaves became a regular, though somewhat restricted, trade, for in that year the Portuguese established a fort on the Gold Coast and commenced the regular shipment of slaves. Forts were also established along the coast of West Africa as far south as Angola near the mouth of the Congo River, the first slaves actually being drawn from the vicinity of the Senegal, Nunez, Benin, and Congo Rivers. By 1539 from 10,000 to 12,000 Negroes were being sold annually, for domestic purposes, in the great slave market at Lisbon. A large proportion of these Negroes were very probably absorbed by miscegenation in the Portuguese population, in much the same manner as occurred later in other countries. However this may be, by 1502 we find evidences of Negroes already well established in the New World chiefly on the island of Hispaniola (the island on which is situated the Republic of Haiti, and Santo Domingo), where they were for the most part employed in the mines. The precise date of the introduction of Negroes into Hispaniola cannot be fixed, but it was probably some time between 1495 and 1500. These Negroes were imported from Spain and were Christians. But with the increased demand for laborers the sale of licenses for the import of "bozel" Negroes (or those direct from Africa) was initiated by Ferdinand in 1513. That year may well be taken to mark the commencement of the Afro-American slave trade.

Without having attempted any highly documented history of slaving in Africa and Europe, we may none the less say with some degree of security (1) that slavery as an established institution over a wide area of Africa was known and practiced long before the appearance of the white man and (2) that in Europe itself the trade in African Negroes as slaves was practiced, in Portugal and Spain, for at least fifty years before the discovery of the New World. Thus, by the time that the importation of African Negroes as slaves into the New World began, the slavery pattern had already long been established among the Negroes themselves as a practice, if not as an institution, with which they were familiar.

Among the discoveries of the New World the trade in slaves for the purposes of domestic labor, not to mention the commercial

profit, had but relatively recently become a strongly established and increasingly vigorous pattern of behavior. With the discovery of the New World the stage was therefore set. Firstly, there were in Africa millions of human beings who were aware of slaving and slavery as a custom which was to some extent practiced among all the tribes with which they were familiar, and who took it for granted that it was not only possible but even desirable to raid or make war against other tribes for the purpose of securing slaves. So that when the Europeans arrived in search of slaves they soon found that it was not war that they had to make in order to secure them, but "gifts"—to the Kings, Queens, and Chiefs who were more than ready to supply the demand of the European "traders." Secondly, the impetus given to the demand for slave labor by the discovery of the New World came at a time when slave-trading had but recently assumed an organized form as a branch of legitimate commerce and was—almost as if it had been timed—ready for the boom in human flesh.

These two patterns of conditions serve to explain both the ease and the rapidity with which the slave trade grew. The fact that the African Negroes had been traded as slaves to Europe for some fifty years before the discovery of the New World serves to explain the readiness with which the Europeans unhesitatingly accepted the suggestion, as soon as it was made, that the labor of Negro slaves was the solution to the first, and most immediate, economic problem of the New World.

## African Origins of the American Negro

For the purposes of this discussion the present limits of the United States will be taken as equivalent to what we shall understand by "America." By Africa we shall mean the whole of that continent in all directions of the compass.

As Herskovits has pointed out, two approaches are possible to the solution of the problem of the African origin of the American Negro, the one historical and the other ethnological.

The historical approach must rely principally upon documentary sources relating to the slave trade, and secondarily upon the recorded observations of travelers.

The ethnological approach relies upon the investigation of African culture traits among American Negroes and the tracing of them to their counterparts in Africa. It is obvious that the ethnological approach forms, at least, a partial check upon the historical method.

We shall deal first with the historical evidence, and finally with the ethnological evidence.

*Historical.* Hispaniola, the island of Santo Domingo which today contains the republic of Haiti, was discovered by Columbus in 1492. There is an unconfirmed tradition that Columbus brought two Negroes with him from Spain on his first voyage of discovery. Since Columbus experienced great difficulty in recruiting a crew, and since Negro slaves were abundant in the port of Palos from which he sailed, this is not unlikely. It is not certain when Negroes were first introduced into Hispaniola, but they must have been introduced very shortly after the second voyage in 1493, for a decade later, in 1502, we find Ovando, governor of Hispaniola, petitioning "that no Negro slaves should be sent to Hispaniola, for they fled amongst the Indians and taught them bad customs, and never could be captured."

By the year 1520, four thousand Negro slaves were being imported annually into all the islands of the Greater Antilles (Cuba, Jamaica, Hispaniola, and Puerto Rico).

When Negroes were first introduced into continental America is not absolutely certain. The date is generally given as 1619 when, as John Rolfe tells in his *General Historie* of John Smith, "about the last of August came in a Dutch man-of-Warre, that sold us twenty negars." This date seems surprisingly late, and will hardly appear credible to those who still labor under the impression that Columbus discovered North America. The fact is that the *mainland* of North America was first seen by John Cabot, in 1497, but no attempt at colonization was made by Europeans until 1562 when the French Huguenots established a colony at a site near the present town of Beaufort in South Carolina, and another, in 1565, in Florida. These colonies were soon ruined. In 1586 Sir Walter Raleigh made unsuccessful attempts to settle a colony of English in

Virginia at Roanoke in what is now North Carolina. It was not until 1607 that the first lasting settlement was made in Virginia by the English, but it was apparently not until twelve years after the settlement of this colony that the first Negro slaves were introduced, in 1619, into North America. From 1569 to 1618 England's only connection with the slave trade was a thoroughly indirect and casual one, coming through the occasional capture of prizes carrying slaves. In the light of this fact, and the fact that the Virginia colony was at the time twelve years old, it may be taken as reasonably certain that Negroes were first introduced into North America in the year 1619. If any Negroes were in existence in the colony before that date, they must have been very few indeed. Thus, the first Negroes to land in America did so exactly one hundred and twenty-seven years after Columbus discovered the West Indies and South America. During this period of time, the West Indies and Brazil had been steadily receiving increasing supplies of Negro slaves; at first, for a short period, Christian slaves from Spain, and simultaneously, and soon exclusively, "pagans" from Africa.

It may be that the Negroes landed from the "Dutch man-of-Warre" in Virginia in 1619 were part of a prize taken by the Dutch somewhere in the West Indies, but for this there is no evidence, as there is none for the origin of these Negroes. On the other hand, it must be pointed out that from the year 1611 on the Dutch had established themselves as slave-traders on the Gold Coast and the Gambia. It therefore seems most probable that the first Negroes to arrive in North America were imported by the Dutch from the Gold Coast, possibly from Mouree, where their first fort, Fort Nassau, was built in 1612. To the Gambia the Dutch had acquired access in 1617, so that it is also possible that our Negroes came from this region of West Africa. By the middle of the seventeenth century the Dutch had substantially displaced the Portuguese hold of almost two centuries upon that coast. The Dutch thereafter carried on their activities from the Gambia to Angola, leaving the Portuguese to the Cape Verde and Gum Coast.

It is desirable to point out here that during the two centuries of Portuguese domination of the Gold Coast much intermixture occurred between the natives and the Portuguese, and it is said that this left a considerable impress upon the physical characteristics of the natives themselves; so that it is possible that some of the Negroes who came to America had some Portuguese ancestry.

After the sale by the Dutch of the first Negroes to arrive on these shores, the rate at which they were thereafter purchased is unknown. As early as 1630, eleven years after the importation of the first Negroes, the Virginia colony found it necessary to provide for the public confession and whipping of a white man-servant for "defiling his body in lying with a Negro."

The period during which Negroes were imported as slaves into America lasted some 240 years, from 1619 to 1860.

The Portuguese, Dutch, British, and French slavers all traded from the coast of West Africa, and between the islands of the West Indies.

As we have seen there is a general belief that the African Negro was brought to North America from almost every part of Africa. Herskovits has strongly combatted this view, pointing out that both the historical and ethnological evidence agree in giving the American Negro a practically exclusive West African origin. A survey of the available evidence indicates that Herskovits is substantially correct in his judgment that the vast majority of the slaves who reached this country came from West Africa. Certainly, slavery in Africa was a continent-wide practice, but Herskovits points out, "Slaves captured in the interior of West Africa or in the eastern part of the continent were much more likely to be taken to the native states of North Africa, to Egypt, or to Arabia than to be brought by way of the dangerous route overland to the West Coast and the slave-ships or to be transported by sea on the long journey around the Cape of Good Hope."

It is probable, nevertheless, that some slaves did reach the coast of West Africa from the interior, but if that was so we have no evidence either as to their numbers or their provenience. It must be remembered that the coast of West Africa, from the Senegal to Angola, extends for a distance of some 4,000 miles. There is good reason to believe that the density of the populations occupy-

ing the coastal regions of this area was quite sufficient to supply the many millions of souls who were shipped from every part of this vast territory to the New World. All the names of native places and tribes mentioned in the existing documents of the trading companies are of West African coastal or near-coastal provenance. Similarly, Ollendorps, a German missionary who was sent out to the Virgin Islands as an inspector of missions, and published a report in 1777, found that the tribal origins of the slaves could all be traced to peoples inhabiting the region from the Gambia River to the mouth of the Niger.

*Ethnological.* With respect to the ethnological evidence it may be said that this, in every way, confirms the above conclusion. Place names, tribal names, customs, language, and music gathered among the Negroes in the New World all point in the same direction, namely, to West Africa.

We conclude, then, that the available historical evidence indicates that the Negroes who were shipped as slaves from Africa to North America were taken from the peoples whose original homes extended all the way from Senegal in the north to Angola in the south along the West Coast of Africa.

### Extra-African Origins of the American Negro

Under this heading we shall briefly inquire into the origins of these African Negroes who found their way to North America indirectly from Africa. Such an inquiry is, of course, of fundamental importance for an understanding of the ethnic composition of the American Negro. Some interesting facts will be seen to emerge.

We have already seen that Negroes were first brought to Europe during the conquest of Spain by the Moors in the latter part of the twelfth century of our era, and that up to the discovery of the New World at the end of the fifteenth century Negroes were steadily being imported into Spain. These Negroes came chiefly from North Africa, and some from the East Coast, and Madagascar. Those from North Africa appear to have come chiefly from the region of the Sudan in the northeast. From the northwest Rio di Oro, the Great Desert regions, Libya and the regions further south, the Arab slave routes led towards Morocco, whence the slaves were sold to all the Moslem states, to Asia Minor and Turkey, to Spain, and to Portugal. Essentially the same regions were later to be exploited by the Portuguese, chiefly for the Brazilian market.

In Spain and Portugal much mixture must have occurred between Negroes drawn from very different parts of Africa, as also between the Moors, the Spaniards and the Portuguese. We shall be justified in regarding the Negro population of Spain and Portugal at the end of the fifteenth century as an already much mixed one. The point is important because the Negroes who were first sent out to the New World were drawn from Spain and later from Portugal.

The number of Negroes who were exported to the New World from Spain and Portugal is unknown. A large number of them, as we know, were Christianized, but we find early references to some who were not, "pagans," and interestingly enough, Berbers—in Hispaniola in 1506. Since such mixed Negroes were later exported to most of the islands of the West Indies and to Brazil, and since some of these mixed individuals later found their way to the mainland of North America, however slight their contribution may have been to the ethnic composition of the American Negro, it is a point which must be kept in mind in any discussion of that composition.

With the discovery of the New World intermixture between the Negroes and the indigenes of the West Indies began almost at once. Thus, as we have already seen, in 1502 we find the newly arrived Ovando, governor of Hispaniola, petitioning the Spanish Court "that no Negro slaves should be sent to Hispaniola, for they fled amongst the Indians and taught them bad customs, and never could be captured." With the increase in the demand for slaves, Negroes were soon being shipped directly from Africa to the West Indies and Brazil, and it is here that the evidence becomes clear that, as far as the West Indies are concerned, very large numbers of Negroes reached these islands who came from parts of Africa which were not restricted to the coastal regions of the western part of that continent.

In addition to the West Coast, the Portuguese are known to have exported slaves to

the West Indies and to Brazil from East Africa, particularly Mozambique.

From the Upper Congo above Stanley Pool, from the Central Niger region, from Hausaland, and from the lower Congo, towards what is now Northern Rhodesia, slaves were drawn in great, but indeterminate numbers. Slaves from these regions were being shipped to the Americas as late as the second quarter of the nineteenth century and, according to Torday, even later.

While it seems clear that many Negroes were brought to the Americas from places in Africa besides the West Coast, it should be equally clear that, owing to the considerably greater remoteness of these parts from the Americas, appreciably fewer Negroes can have been brought from them than were brought from the West African coast.

Thus, again we must conclude that the majority of the Negroes who reached the New World were predominantly of West African origin, but that there were also appreciable numbers among them who were derived from North-Central, South-Western and East Africa. It must be supposed that these Negroes were already very thoroughly mixed, among themselves and with the Indians of the islands and of the mainland of Brazil, by the time most of them reached North America.

It is known that many of the slaves imported into the English colonies came by way of the West Indies, and unquestionably some of these were of mixed blood. The mingling of Negroes and Indians, of course, occurred first in the West Indies. Interestingly enough, there seems to have been an appreciable amount of inter-island trading in Indians and Negroes, and lots of the one were occasionally exchanged for the other. Thus, for example, Indians and Negroes were simultaneously introduced into the Bermudas for the first time in 1616, the supply being continued through importation of Negroes from Africa and "redskins," the latter sometimes in exchange for Negroes. Many of the colored people of Bermuda are said to show in their physiognomy the influence of the Indian type.

## Ethnic Mixture of the American Negro

From the very beginning the American colonies held Indian and Negro slaves. The principal effects of the relation between Negroes and Indians as fellow slaves has been summed up by Reuter:

> Slavery of the native Indians existed in a number of English colonies before the coming of the Negroes. Those captured in battle were in some cases sold into slavery in distant colonies. Others were kidnapped along the coast and sold as slaves in the more settled regions. . . . With these enslaved Indians the Negro slaves came into close and intimate contact. The social status was the same and as slaves they met on terms of equality. Intermarriage following and, as the body of Negro slaves increased and Indian slavery declined, the Indian slaves were gradually absorbed into the larger black population.

One of the most interesting results of Indian-Negro contacts was the development of a regular slave-trade among certain Indian tribes. Thus, for example, the civilized tribes in the Indian Territory did an appreciable trade in Negro slaves. A government investigator in 1841 and 1842 reported that "Comanches steal Negroes sometimes from Texas and sell them to Cherokees and Creeks. The latter have been known to pay $400 and $500 for a Negro."

The available evidence indicates that mixture between Indians and Negroes has been of vastly greater proportions than has hitherto been realized.

At least two Indian tribes, the Creeks of Georgia and an offshoot of the latter, the Seminoles of Florida, were completely Africanized. The Seminoles, or "runaways," treated their Negro slaves virtually as equals; and in the Seminole wars the Indians and Negroes fought side by side.

Negro-Indian mixture has occurred, to a greater or lesser extent, throughout America. Such intermixture has proceeded down to the present day wherever Negroes and Indians have come into contact. In recent years there has been some mixture between Negroes and Mexican Indian peons brought into the sugarbeet plantations in Kansas.

Negroes look upon Indian ancestry as something of which to be proud. Thus, 27.3 percent of the Negroes—out of a total of 1,551 individuals—examined by Herskovits claimed some Indian ancestry. At the present time, however, no significant admixture of Negro and Indian stocks is in progress.

## Negro-White Mixture

Until the publication of Herskovits's classical studies the enormous extent of Negro-

white admixture was hardly realized even in the best informed quarters. At the present time it is still impossible to make any definite statement as to the number of Negroes in America who have some white ancestry, and the number of whites who have one or more Negro ancestors. Census returns are of little value here owing to the arbitrary methods of classifying Negroes, Mulattoes, and whites. All that it is at present possible to say is that it is probable that the majority of Negroes have some white ancestry. According to the 1920 census some 20.9 percent of the Negro population consists of Mulattoes. Writing as an anthropologist with genetical interests, the present writer would put that figure nearer 80 percent if we take the term Mulatto to refer to the presence of some white ancestry in an individual of primarily Negro origin. This figure of approximately 80 percent is confirmed by Herskovits's finding on a representative sample of 1,551 Negroes.

The Negroes have from the earliest days mixed with all classes of the white population, the mixture for the most part being between Negro women and white men.

During the Colonial period, when white women were scarce, Negro women naturally received a great deal of sexual attention from the pioneer whites. During the period of slavery, the slave owners and their sons frequently made free of such Negro women as took their fancy. Thus, there was a good deal of mixture between "upper class" whites and Negro slavewomen. Up to the present time the polygynous relationship in which a white married man maintains a colored woman, and his children by her, persists in many parts of the United States.

Actually, our knowledge of the relative frequencies with which members of the different classes among whites are responsible for miscegenation is quite unknown, but it is a safe inference that all classes of the white population are involved.

Negroid individuals from other parts of the New World have not entered America in very large numbers, but such as have entered have certainly been quickly absorbed in the American Negro population, and there can be little doubt that in certain localities, particularly on the eastern seaboard, they have helped to modify somewhat the physical type of the Negro. That modification, however, has always been towards the Negro side of the balance rather than otherwise. But this is a matter upon which evidence is conspicuously lacking.

That the Negro population every year loses some of its members by "passing" of those who may "pass" for whites is certain, and although the number who do so is unknown, the proportion who are thus lost is probably negligible. "Passing" has little, if any, effect upon the physical character of the white population since an individual who passes from the Negro to the white group must genetically be considered white. The birth-rate of the Negro population so far exceeds the death-rate that such losses by passing can be considered to play no significant role in limiting the size of the Negro population. The physical character of the Negro population is, however, definitely affected by passing, for the "passers" were potential lighteners of skin color, and in that sense they represent a definite loss to the Negro population which, on the whole, prefers lighter skin colors to the darker ones. Since dark men tend to marry lighter women, it seems clear that the Negro population is destined to become stabilized around a skin color which is definitely "black" or dark-brown, though somewhat lighter, on the average, than that of the true West African Negro.

## The Ethnic Composition of the Negro Population Today

The American Negro population of today is a composite of African, white, and Indian elements. The American Negro is often described as a *hybrid*. But a hybrid is the offspring of two distinct lines, and the American Negro is rarely, if ever, that. He is, on the other hand, the end-product of many lines. He is, firstly, a much mixed African who has, secondly, been much mixed with a large variety of whites—Spanish, Portuguese, Dutch, British, and French—and, thirdly, there has been a considerable addition to this admixture in the form of the New World and American Indian. The American Negro population, we may say with Herskovits,

> combines the traits of its ancestral racial types, and has so blended them that any given feature is about

equidistant between the typical African feature, on the one hand, and the typical European and American Indian features, on the other. We can therefore say . . . that the American Negro resembles all of his ancestral types, and yet is none of them. He is distinctive among human beings. Varied though American Negroes may seem to our untrained eyes, when we actually test the extent of this variation, we find that it is no greater than that found among any of the so-called "pure races" from which they have come.

### Reproductive Differentials and Probable Future of the Negro

Census figures show that the Negro population has increased from 757,208 in 1790 to 11,891,143 in 1930. The percentage of Negroes in relation to the total population in 1790 was 19.3, whereas in 1930 that percentage was only 9.7.

This difference is, of course, not due to a decline in the relative fertility of the Negro, but reflects rather the disproportionately greater increase of immigrant whites into this country as compared with the comparatively insignificant immigration of Negroids. Since immigration of whites is now much restricted we may expect a relatively marked increase in the numbers of the Negro population. Recent studies of the Negro population problem show that the Negro is now reproducing at a more rapid rate than the white. In 1930 the birth-rate of Negroes in the Registration area was 21.6 per thousand population compared with 18.7 for whites. The birth-rate of Negroes per thousand enumerated females in the reproductive ages, 15 to 45 years, was 82.5 and that of whites 78.4. The average number of children born to mothers who had been delivered of a child in 1930 was 3.6 for Negroes and 3.1 for whites.

The Negro death-rate is everywhere in America higher than that of the whites. Thus in 1930 the death-rate per 100 persons was for Urban Negroes 22.8 as compared with 12.0 for whites, and for Rural Negroes 17.0 as compared with 9.5 for whites. Infant mortality is about 60 percent higher than that of whites. For the same year the total Negro death-rate was 16.92 as compared with 10.91 for the whites.

As all investigators are agreed, the high Negro death-rate merely reflects the poor health conditions under which Negroes are for the most part forced to live. The mortality has been chiefly due to preventable diseases, and as soon as something is done to improve the health services and the conditions of life under which the Negro population struggles for existence, there can be little doubt that both the Negro and the white mortality rates will very appreciably decline.

The reproductive tendency of Southern Mulatto families has been slightly higher than that of black families living in the same localities.

The better socio-economic status of the Mulatto must here, on the whole, be held accountable for his superior reproductive tendency.

The prediction of population changes is at best a hazardous affair. Too many variables are involved, and it is quite impossible to predict the future history of all these variables with any degree of certainty. On the basis of certain assumptions, however, which have been made by Whelpton, a relatively greater increase is predicted for the Negro population between 1930 and 1980, when Negro females may increase by more than 49 percent and white females at little less than 36 percent. All students of this subject agree that a relatively greater increase of the Negro population is something which can be predicted with certainty, having regard to the observable trends in the variables concerned and of the Negro population itself. For the next hundred years, at any rate, it may be confidently predicted that the color of the Negro population will tend towards a more uniform distribution of the darker shades, so that we may expect a larger Negro population more uniformly dark-brown colored, or "black," than the present Negro population of America.

# POPULATION PROBLEMS OF A NEW WORLD ORDER

By KARL SAX

PROMISES of an abundant life and freedom from want for all peoples of all nations seem to be made with no consideration of agricultural production or population pressure. The universe may be expanding, but this world is not, and already many parts of the world cannot support the existing populations at much more than a subsistence level. Man lived and multiplied on this earth for five hundred centuries before the population reached 850,000,000 people, but at the end of one additional century the world population had doubled. During the recent past the world population has been increasing at the rate of one percent a year, a rate which would nearly double the present population before the end of this century.[1] There are now forty persons per square mile of land area in the world. The population density of the United States is almost exactly that of the world as a whole. Some parts of the world have high population densities; other areas are sparsely populated. In some areas the populations are growing rapidly, while in other regions the population is at a stationary level. It is the differential population growth and density in various parts of the world that present difficult problems in establishing global unity so essential to world peace and security.

## I

It is estimated by competent authorities that about two and one-half acres of arable land are needed to provide a human being with essential food, clothing, and other necessities.[2] The total area of all crop land in the world is about four billion acres, according to Dr. H. H. Bennett, head of the United States Soil Conservation Service. The world population is now over two billion, so that the cultivated land per capita is only two acres. There is more land that can be cultivated in many parts of the world, but most of it can be farmed only with diminishing returns or at a much greater cost of production. Many regions of the world are already overpopulated on the basis of domestic agricultural production. With the exception of Russia, practically all the nations of Europe and Asia are no longer able to produce enough food to maintain adequate nutritional standards. The population of large parts of Asia manages to live on less than one acre of arable land per capita, but the masses do little more than survive and many do not even do that very long. Millions of acres have been exhausted by continued cultivation and erosion, and no new acres are available in these densely populated areas. The answer to the population problems of Europe and Asia would seem to be the proper distribution of either the populations or the food supplies of the world, but in practice this solution is not at all simple.

When population pressure exceeds the food supply, as it does in many parts of the world, there are several paths of escape. The overcrowded nations of Europe have followed three methods. Industrialization and modern methods of transportation have enabled these nations to maintain populations whose food requirements exceed their own agricultural production by importing food in exchange for manufactured products. Population pressure also has been relieved by the migrations of the people of Europe to the new nations of the Americas, Australia, and Africa. These two methods are possible only when other parts of the world can still support larger populations or can produce a surplus of food products. The third method followed by the peoples of Europe, in spite of legal and religious bans and the exhortations of priests and politicians, is the artificial reduction of the birth rate. Most of the European countries have reduced their birth rates during the past fifty years from over thirty per thousand to less than twenty per thousand. In fact, many of these countries —England, Germany, France, Austria, and

[1] R. Pearl, *Natural History of Population*, 1939.
[2] P. E. Brown, "Land and Land Use," *Science*, 83: 337–343, 1936.

the Scandinavian nations—have had birth rates below replacement levels, and nearly all the others are rapidly approaching a stationary or diminishing level of population. Of the countries of Europe, only the Slavic nations have anything approaching the "natural" birth rate of forty per thousand, and only Russia has agricultural resources to support a much larger population. As the socio-economic conditions improve in Russia, her birth rate too will decline.

Population pressure in Asia is even greater than it is in Europe, but the nations of Asia have found no satisfactory solution. More than half of the world population lives in Asia, with little relief from population pressure by migration, industrialization, or birth control. Only Japan has developed industries sufficient to permit her to import a considerable part of her food supply. Industrialization and aggression have enabled Japan to double her population during the past fifty years, but the increase is maintained only by low standards of living and long working hours. China and India have birth rates considerably higher than Japan's thirty per thousand, but their populations have grown more slowly, because these countries have been unable to provide for a rapidly growing population. The Malthusian law operates with little restraint in continental Asia. Population has increased faster than food supply and has been held in check only by famine, pestilence, and natural catastrophes.

Can the people of Asia meet the problems of population pressure? What are the prospects of increased food supply, migration to sparsely populated regions of the world, or reducing birth rates to the level of agricultural production?

Food production in Asia cannot be increased appreciably. Most of the agricultural land already is in cultivation and, owing to intensive cultivation, produces more per acre than our farm land. The farms are small, averaging two and seven-tenths acres in Japan, three and three-tenths acres in China, and a little more in India. Three-fourths of the population derives a living from agriculture.[3] Modern agricultural methods would result in little increased production, although they would release many people for the development of essential industries.

Industrialization of Asia can increase the food supply only so long as other nations are able to produce a surplus of agricultural products. The leading food exporting countries are Russia, Argentina, Canada, and Australia. Russia, with her resources and modern methods of farming can export large quantities of food after the war, but if her birth rate remains at forty per thousand, Russia will, in another generation, require all the food she can grow. Improved socio-economic conditions in Russia probably will reduce the birth rate, but this will be offset by higher living standards. Argentina is able to export a third of the food she produces, and Canada one-fifth. Europe alone will require most of the exports of both Australia and Canada. These and other food exporting countries can supply a considerable agricultural surplus for some years, but most of them are growing rapidly and will have little surplus food for export in another generation.

Emigration offers little hope for Asia, because most of the other regions of the world are already populated or controlled by the white races. It seems improbable that Australia, Canada, the United States, and the countries of South America will welcome large numbers of Asiatics with any greater enthusiasm in the future than they have in the past. Most of these nations will acquire their own optimum populations in a relatively short time, without the questionable benefits of Asiatic immigration. Certainly there is no moral reason why those nations which restrain their birth rates to improve their standards of living should provide for the surplus populations of other countries which breed without consideration of the economic and social consequences.

Invasion of neighboring countries, already overpopulated, provides no more *Lebensraum* for the invader unless the peoples of the conquered nation are exterminated. Such a practice cannot be tolerated in a civilized world. Nor is there any biological justification for the myth of racial superiority, which has been used by the Nazis as an

[3] G. B. Cressey, "Agricultural Regions of Asia," *Econ. Geogr.*, 10: 109–142, 1934.

excuse for their attempts to enslave or exterminate neighboring peoples and racial elements of their own population.

Let us assume that we can help feed and industrialize Asia and increase the standard of living. So long as birth rates of forty to fifty per thousand persist, the population will increase just as fast as food supplies and medical science will permit. The only rational solution of population pressure in Asia is the reduction of the birth rate. But among both nations and individuals the practice of birth control tends to be limited to the more fortunate socio-economic groups. The social and economic conditions in Asia would seem to preclude any general practice of birth control, unless recent advances in contraceptive methods make birth control more generally available and practicable than is now the case.

## II

Many misguided optimists believe that there will always be enough for all regardless of the number of people who occupy the earth. Such optimism is not limited to newspaper columnists, such as Dorothy Thompson, who assures us that there is "enough for all" in this world of modern science. J. D. Bernal, a reputable English scientist, suggests that if we could convert coal and limestone into food materials "we should have enough food for a population thousands or millions of times that which exists at present."[4] An increase of one thousand times would establish a population density of 40,000 persons per square mile of land surface of the world, while an increase of a million times would mean that there would be less than one square foot of land area available for each person! Nor is Bernal's faith in agricultural science shared by those who know something about the subject. It is true that England can support one person per acre of cultivated land, but it can be done only by intensive cultivation, liberal use of fertilizer, an exceptionally favorable climate, and a low standard of living for a large part of the population. Her agricultural index of productivity is one hundred and seventy-seven compared with the world average of one hundred, but this does not mean that the rest of the world can reach England's level of productivity.

It is true that science has made almost incredible contributions in the field of communication, transportation, production, and labor-saving machinery. Scientists will continue to work miracles for the benefit of mankind, but it is improbable that they can do much to increase agricultural production. During the past fifty years, plant breeding, crop rotation, the use of fertilizers, pest and disease control, and the use of modern agricultural machinery have increased yields per acre by as much as forty to sixty percent in the United States. This is a remarkable increase, but it has been almost completely offset by the deterioration of the natural soil fertility and by new problems in pest and disease control. According to the U. S. Department of Agriculture Yearbook for 1938, we are little more than maintaining crop yields at a stationary level in spite of remarkable advances in agricultural science. The same trend is true in other countries. Some nations have higher yields per acre than we do, but largely because of more intensive cultivation and less production per man. The American farmer cultivates an average of twenty acres; in Belgium one man cultivates only five acres; and in China the average area cultivated per man, or woman, is less than one acre.[5] One-fifth of our population can produce sufficient essential food with a surplus for the "ever normal granary," but in China three-fourths of the workers are engaged in farming and produce only enough food for minimum needs, with little or no surplus for lean years. Whenever a large proportion of the population is required to produce the food supply, the standard of living for all is maintained at low levels. We could produce more food by more intensive cultivation and by using more submarginal land, but this could be done only by lowering the living standards of the entire population.

Since the world population density is approximately that of the United States, a further examination of our population and our resources is of particular interest. The United States is well endowed with natural

[4] J. D. Bernal, *The Social Function of Science*, 1939.

[5] E. M. East, *Mankind at the Crossroads*, 1926.

resources for a high degree of industrialization and has large areas of fertile land for agricultural production, but in normal times we just about balance food imports with food exports and ship to foreign countries only about ten percent of our American-grown food. We can produce more food but not enough to feed many more people either here or abroad. According to the U. S. Department of Agriculture Yearbook, the present crop land area is somewhat more than four hundred million acres, but of this area about sixty percent is subject to erosion under current agricultural practices, or is too poor to farm at a profit. Half of this land subject to erosion or too poor to farm profitably should be retired from cultivation. Of the land not now in cultivation, less than fifty million acres should be used. Thus if we include all crop land of any value which can be maintained in cultivation, the total is about three hundred and seventy million acres or less than three acres per person. At present, we use over three acres of arable land per person, and still we do not provide adequate food for a large part of our population. According to the Food Nutrition Board of the National Research Council, our pre-war diet was deficient by the following amounts: fresh vegetables fifty-nine percent; milk forty-five percent; citrus fruits and tomatoes twenty-eight percent; beans, peas, and nuts twenty-five percent; eggs seventeen percent and meat, poultry, and fish only four percent. Cereals were adequate, and there was an excess of fats and sugar. The deficiency of protective foods is largely a problem of economics, but these foods are expensive to produce and distribute.

There may be a temporary solution of the food problem, without relying on the chemists to produce food from air, sawdust, and coal. Our normal diet consists of about forty percent animal products—meat, eggs, milk, and cheese. It requires six to eight times as much land to produce food in the form of meat and milk as it does to produce the basic cereal and legume crops. The reduction of animal products in our diet would release more of the basic food crops for human consumption. Recent work done at the Massachusetts Institute of Technology seems to show that the basic cereals and legumes, fortified with essential minerals and necessary vitamins, can provide an adequate diet without meat and milk or even without fresh vegetables and fruit. Such a diet would be as satisfactory as that enjoyed by the European peasant or the Asiatic coolie, although it might be more monotonous. In normal times this basic diet should be supplemented with the usual foods we enjoy, but in an emergency it would provide more food for more people.

Actually there is little need for the Occidental peoples to look forward to synthetic food supplies or a cereal diet. Their growth rate is becoming adjusted to agricultural resources, and with few exceptions those countries with limited resources have reached a stationary or diminishing population. Recent trends in the United States indicate that our population will be stabilized at about one hundred and sixty million. It is only in the Asiatic countries that population pressure is likely to exceed any possible increase in food production. Is the Occidental world going to adopt Oriental standards of living in order to feed and industrialize the peoples of Asia? It seems premature to speak of raising the standards of living for all races, when even the richest Occidental nations are unable to provide a reasonable standard of living for a large part of their own populations. During the past year the exportation of only six percent of our food supplies to our allies and increased consumption of food by our war workers and soldiers have led to a food shortage in spite of the fact that we had bumper crops in 1942.

## III

The decline in birth rates in the western world has done much to reduce population pressure, but it has raised other problems which threaten the internal security of these nations. The threat which disturbs political and religious leaders is the fear that their nation or their sect will be submerged by more rapidly breeding nations or religious groups. France is often cited as the horrible example of the consequences of birth control. France has long had an approximately stationary population, but in the years before the present war France had a higher stabilized rate of natural increase in population

than did Germany, England or the Scandinavian countries. If all the countries of Europe had reduced their birth rates when France did, there would have been little excuse for more *Lebensraum.* If manpower were the determining factor in war, a population race between France and Germany would mean the defeat of France, simply because Germany has resources to support a larger population, just as Russia is destined to control all of Europe if she so desires. In a peaceful world there would be no need for expansion of population to the limits of subsistence, and each nation could maintain an optimum population level in accord with adequate living standards for all. Even in a world at war, a large population does not necessarily imply military might. China has at least five times as many people as Japan.

In all countries in which the practice of birth control is prevalent, the differential birth rate between the different economic and educational classes is a matter of considerable concern. The situation in the United States is typical of most Occidental nations. According to Lorimer *et al.*, in *Foundation of American Population Policy,* the urban white families with annual incomes of over $3,000 had a reproductive index of only 0.46, while those with earned incomes of $1,000 a year or less had about twice as many children. But the only class which exceeded replacement levels in 1935 were those on relief, with a reproductive index of 1.43. Does this trend indicate that we are approaching the conditions of a termite society in which a specific caste is maintained only for the purposes of reproduction? Even in normal times the third of our parents least able economically to raise and educate children produces two-thirds of our future generation. The same trend is found in relation to education. College graduates have relatively few children as indicated by their reproductive index of 0.57, but those with less than a seventh grade education have had a reproductive index of 1.18. Fortunately our rural population has a considerably higher birth rate than our urban groups.

The dependence upon the poorer and more ignorant members of society for the major portion of our future generation is not conducive to the best development of the individual or the nation. If poverty and ignorance are the result of bad heredity, the excessive fertility of this group will result in the lowering of the average capacity of the population. If, on the other hand, the more unfortunate members of society are the result of poor environmental conditions, the consequences are equally serious because such parents cannot provide a favorable environment for their children. Actually both heredity and environment are responsible for individual development. Man is subject to the laws of heredity in both physical and mental development, but the relation between inherent ability and success is so obscured by environment that it is difficult to determine an individual's innate mental capacity. The mental defectives belong to a special category, and there is no question about their undesirability for parenthood.

Why do those who are least able to feed, clothe, and educate children have much higher birth rates than the more able, or more fortunate, members of society? The late Dr. Raymond Pearl, of Johns Hopkins University, has provided the answer based upon a survey of more than 30,000 women in urban maternity hospitals in the United States. Differences in birth rates among the various racial, economic, educational, and religious groups are due almost entirely to differences in the prevalence and effectiveness of the practice of artificial contraception, and to a minor degree to differences in age of marriage and the practice of criminal abortion. Among the rich and well-to-do, eighty-three percent of the mothers with more than one child practiced contraception, while among the very poor classes only thirty-five percent used, or attempted to use, contraceptive methods. Pearl's detailed records show that these poor mothers had large families due primarily to ignorance of contraceptive methods and to irresponsibility, rather than to a desire for many children. This conclusion is supported by a survey made by the *Ladies' Home Journal,* in which it was found that practically all married couples want children and that nearly all want more than one, but that relatively few want more than four.

The greatest enigma of this age of science

is the present status of the knowledge and practice of contraception. Public opinion surveys made by the Institute of Public Opinion and by the *Ladies' Home Journal* show that more than three-fourths of the people of this country approve of the dissemination of birth-control information by the medical profession and even of government-supported birth-control clinics. Dr. Pearl's data show that the majority of married women practice, or think they are practicing, some form of artificial contraception.[6] Yet our archaic laws prevent the dissemination of reliable information and keep the $250,000,000 contraceptive industry on a semi-bootleg status.[7] This seems particularly inexplicable in view of the fact that religion is no longer an important factor in suppressing such information. Nearly all the Protestant churches approve of artificially controlled birth rates, and in 1930 Pope Pius gave at least implied approval of "natural" birth control.[8] Although the Catholic Church still opposes artificial contraception, it is practiced by Catholics to about the same extent as it is by Protestants of similar economic and educational status.

Both nations and families are confronted with the same problems. If they have more children than they can feed and educate, they are doomed to lower living standards and higher death rates and are handicapped in economic and cultural development. But if they do curtail birth rates they are in danger of being overrun by the unrestricted breeding of their neighbors. The logical solution would seem to be the control of birth rates in accord with the national or family resources. At the same time, every effort should be made to insure equal opportunity for all. Only with equality of opportunity can the inherent capacities of all individuals be fully developed.

The history of both empires and families seems to show that a relatively high degree of culture and economic success tends to be followed by degeneration or extinction, just as in evolutionary history those species which developed a high degree of specialization often failed to survive, while more degenerate or more aggressive species survived and flourished. Evolution does not guarantee progress, but only change. Man has been able to control his environment to a remarkable degree, and there is no reason why he should not be able to control his social evolution. But it cannot be done by abandoning rational thought and reverting to mysticism. We need more of the scientific method, particularly in the field of social relations and human conduct.

The control of the birth rate is an established feature of Occidental civilization, and it must be adopted by the Oriental nations if the problems of population pressure are to be solved. The world cannot remain half slave and half free in control of population growth. There is not enough for all in many parts of the world, and unrestricted population growth in these areas can lead only to aggression or to chaos. Unrestricted birth rates not only are a threat to world security, but also they involve the freedom of the individual. This freedom must be extended to all classes and to all races if there is to be equal opportunity for all.

6 Less than five percent of the contraceptors use methods recommended by most birth control clinics.

7 "The Accident of Birth," *Fortune*, 17: 83–86, February, 1938.

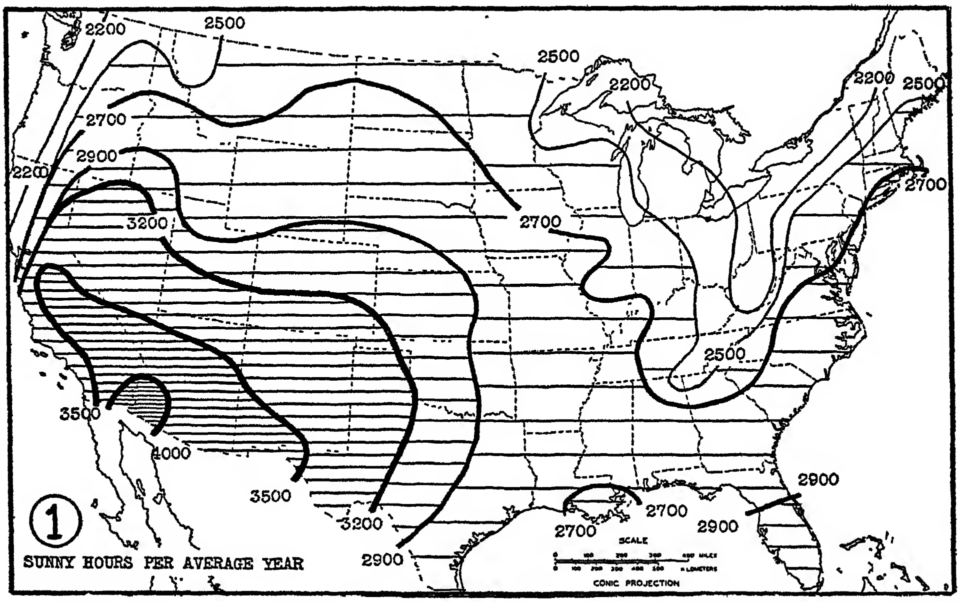
8 In Boston we are still told that "birth control is against God's Law."

# SUNSHINE AND CLOUDINESS IN THE UNITED STATES

By STEPHEN S. VISHER

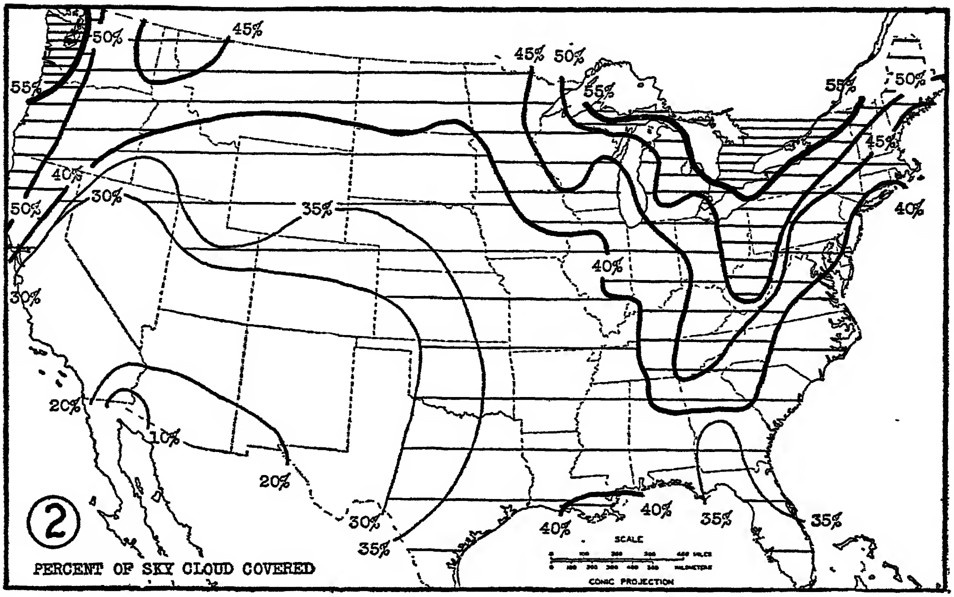
SUNSHINE is a climatic factor of diverse and profound significance, for it sharply affects the amount of heat received by the surface of the earth from the sun. Sunshine is also an increasingly recognized health-giving influence. In parts of the world where sunshine is inadequate, at least for a part of the year, human health is adversely affected. This is especially true of children who fail to develop properly in cloudy areas unless the natural sunshine is supplemented by "bottled sunshine" (fish liver oils) or ultraviolet light. Bright sunshine, however, may be harmful to various animals, especially insects, and to many delicate plants, and sometimes to man.

The amount of cloudiness strongly affects the temperature by night as well as by day. In all seasons, cloudy days are generally cooler than clear ones, but cloudy nights are distinctly warmer than clear ones. This is because the clouds serve as a blanket. The amount of cloudiness also affects the beauty of the sky. For example, stars on clear nights make the sky beautiful, and scattered clouds add to the beauty of a moonlit night. Clouds add greatly to the beauty of dawn and sunrise, and of sunset and evening. Grey, overcast skies, on the other hand, reduce all the colors of nature and have a depressing effect upon most persons. Studies by Ellsworth Huntington indicate, nevertheless, that although most people prefer bright weather following a cloudy period they usually accomplish less work on a clear day than on a partly cloudy one. A long succession of clear days has a depressing effect, as is evident from the sense of relief commonly felt when clouds return, as for example in southern California after the almost cloudless summer.




MAP 1. AVERAGE NUMBER OF HOURS OF SUNSHINE PER YEAR

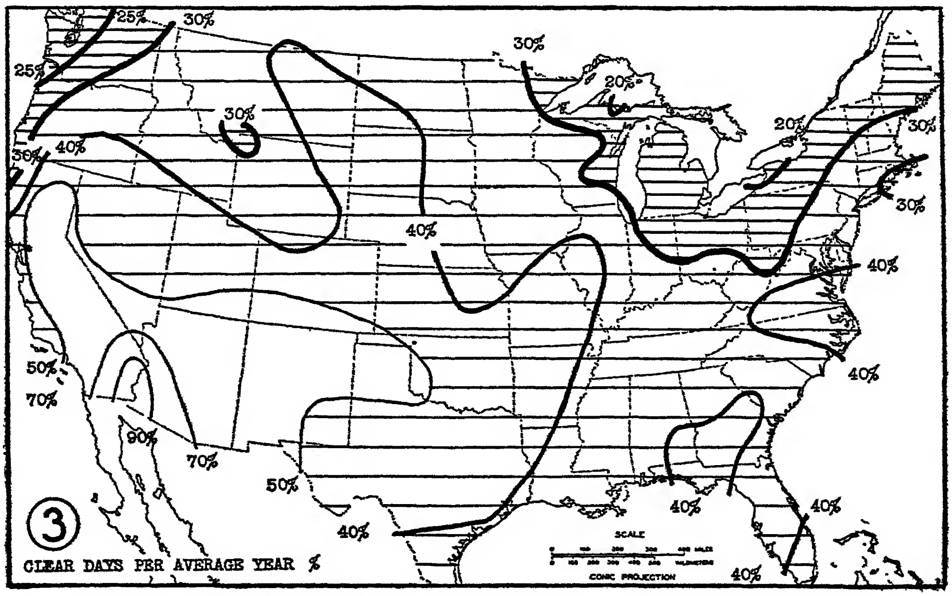
Within the United States there are notable regional differences, and also sharp seasonal contrasts, in the amount of sunshine received. The accompanying maps, based on official Weather Bureau data gathered at the approx-



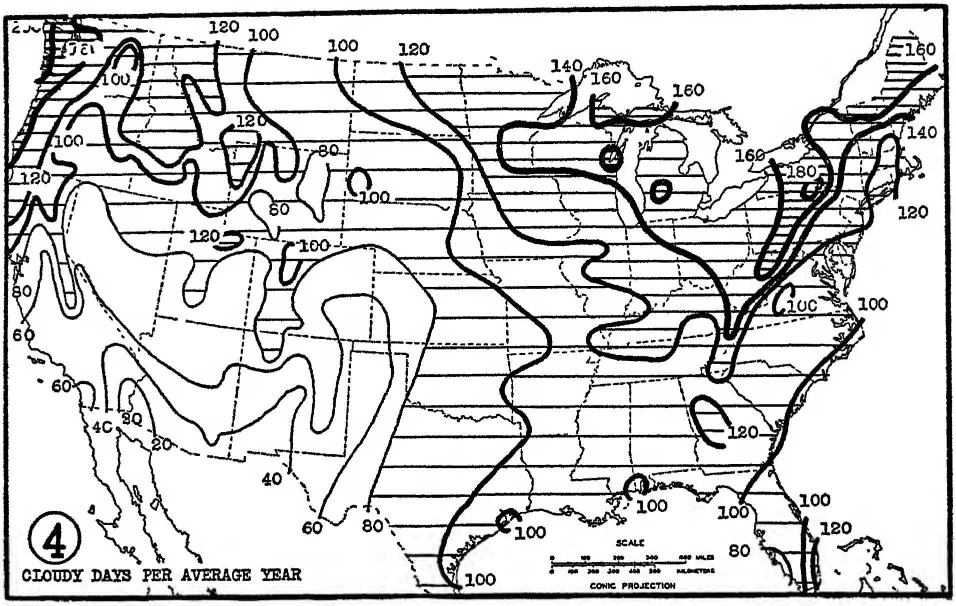

MAP 2. AVERAGE PERCENTAGE OF SKY CLOUD-COVERED BY DAY

imately two hundred first order stations, present various aspects of widespread interest.

Map 1, of the annual average number of sunny hours, shows that the Pacific Northwest and a part of the Northeast receive on the average less than 2,200 hours of sunshine a year, or an annual average of less than six hours per day. Southern Florida and a large southwestern region receive, however, more than 2,900 hours a year, which means an average of more than eight hours a day. A considerable southwestern area receives ten hours a day, on the average. This map shows a general decline northward in the amount of sunshine received per year. Exceptions occur, however, in areas near the Pacific Coast and near the Great Lakes, both of which receive considerably less sunshine



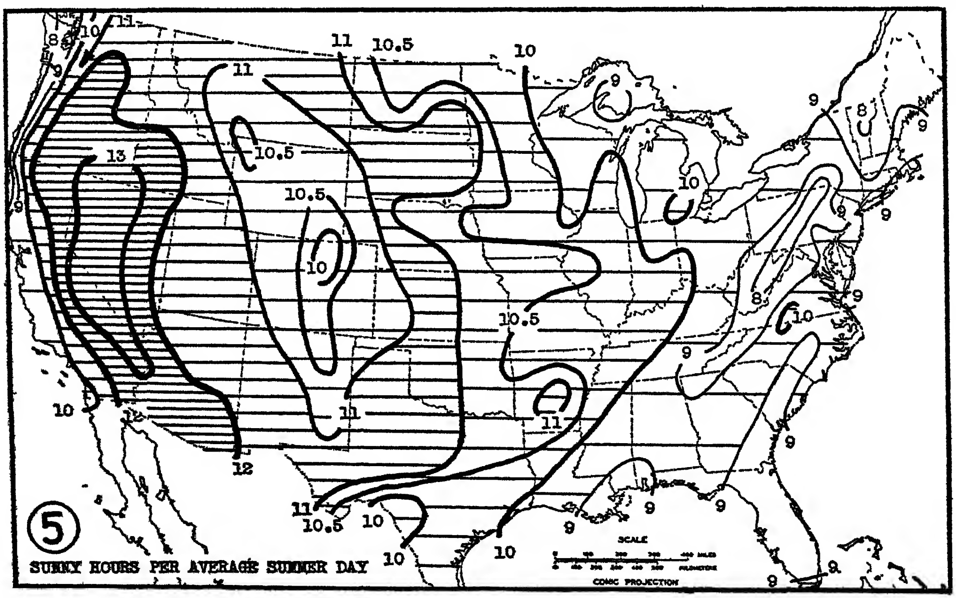

MAP 3. AVERAGE PERCENTAGE OF CLOUDLESS DAYS PER YEAR




MAP 4. AVERAGE NUMBER OF CLOUDY DAYS PER YEAR

than similar latitudes nearby. The southern Appalachian Mountains also are relatively cloudy, as is implied by their popular name, "The Great Smokies." The greater sunshine in the Southwest than in the Southeast is due, of course, to its aridity. Map 1 is original, based on all the records of the first order stations to 1931.

Map 2 shows the average percentage per year of the sky which is cloud-covered by day. It will be noted that along the northern Pacific coast and in a large northeastern region, the sky is half cloud-covered on the average. In Florida it is cloud-covered more than a third of the day time, but in a large southwestern region it is cloud-covered less than one fourth of the day time. This original map is based on the difference between




MAP 5. AVERAGE NUMBER OF HOURS OF SUNSHINE PER SUMMER DAY

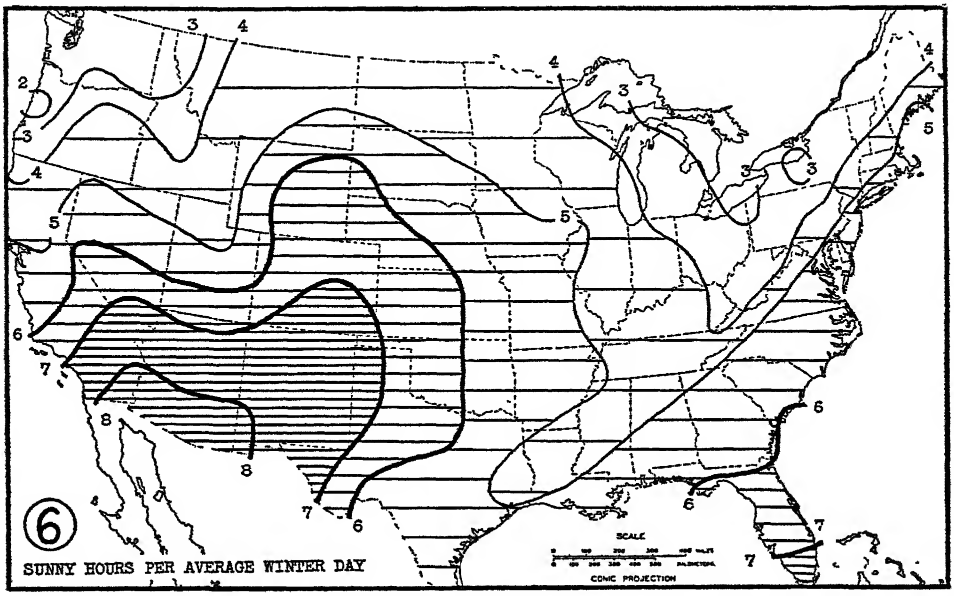
one hundred percent and the published "annual percentage of possible sunshine."

Clear days (map 3) are twice as frequent in the Southwest as in the Northeast or Northwest. Indeed, in the Imperial Valley near the mouth of the Colorado River, more than nine-tenths of the days are clear, while parts of the shores of the Great Lakes have less than one-fourth of their days clear. This map is a shaded copy of one by Kincer in the *Monthly Weather Review* for 1920.

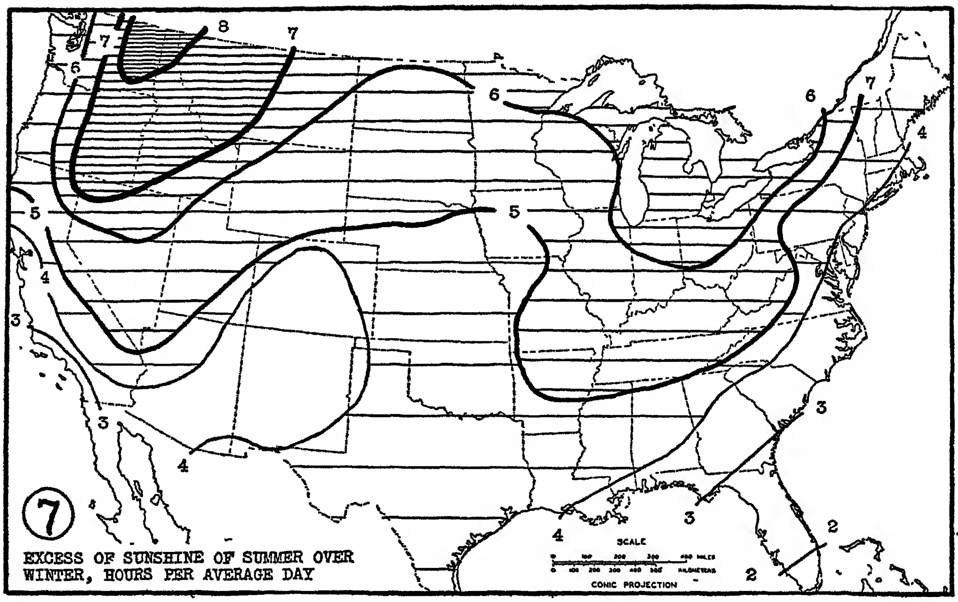
Cloudy days (map 4) occur only rarely in southern Arizona where Yuma has fewer than twenty per year. Moreover, on most of those that are cloudy the sun is seen either at sunrise or at sunset. To emphasize this fact, the Yuma hotel advertises that it does not charge its guests for board or room on any day that the sun does not shine. It very seldom fails to charge. In sharp contrast to southern Arizona, several areas bordering the Great Lakes have on the average more than one hundred and sixty cloudy days a year, while in western Washington the number of cloudy days is greater than two hundred per year. This map is a redrawing of one in the 1941 Yearbook of the Department of Agriculture, *Climate and Man.* (The Yearbook maps were made under the direction of J. B. Kincer.)

Seasonal contrasts in sunshine are shown in maps 5–7, 5 and 6 of which are redrawn from those in the 1941 Yearbook. Map 5 shows that in summer the eastern third of the country receives on the average less than ten hours of sunshine a day. The northern half of that eastern third receives fully as much as the southern half, partly because in the North the days in summer average more than an hour longer than in the South. The cloudiest eastern regions are in the Appalachians and northern New England, partly because of greater convection in mountainous areas. On the Pacific Coast there are, on the average, three or four fewer hours of sunshine per summer day than there are a short distance inland from the coast, much of this difference being due to fog. The Great Plains are notably less cloudy in summer than the East or the Rockies, proving that the author of "Home on the Range" was correct in his observation that there "the skies are not cloudy all day."

Map 6 shows that in winter the Great Lakes region and adjacent areas to the east and southeast receive less than four hours of sunshine during an average day, while the North Pacific coast receives only two to three hours a day. Florida is notably sunny in winter as compared with much of the North-




MAP 6. AVERAGE NUMBER OF HOURS OF SUNSHINE PER WINTER DAY




MAP 7. AVERAGE EXCESS IN HOURS OF SUNSHINE OF SUMMER OVER WINTER

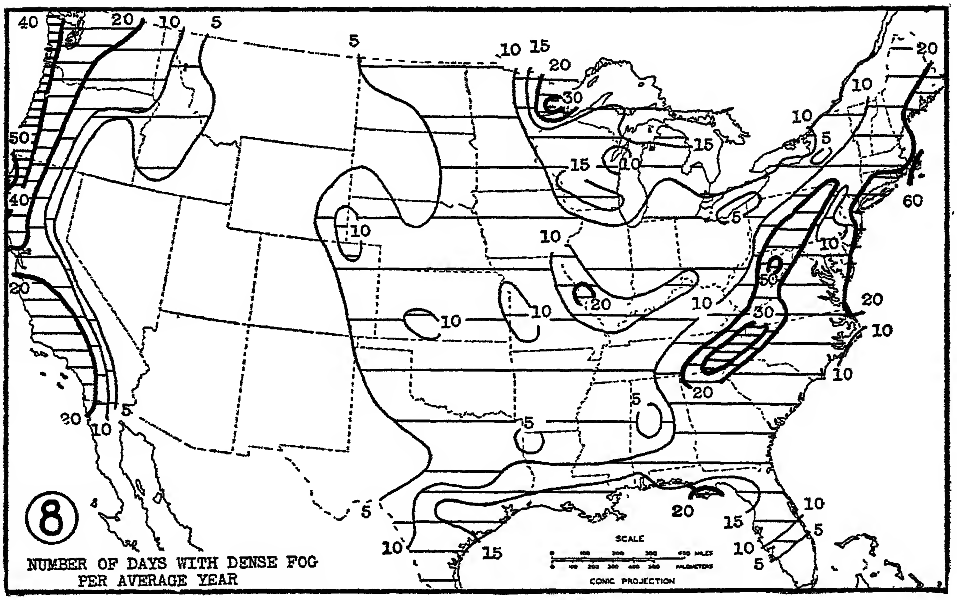
east, but the sunniest region is the Southwest, with an average of 7 to 8.5 hours of sunshine per day.

Map 7 shows the difference between the daily hours of summer and winter sunshine. This original map reveals that in Florida a summer day receives on the average only from two to three more hours of sunshine than a winter day but that near the Great Lakes the average for the summer is about six hours more than for the winter. Residents of the Great Lakes Region naturally appreciate Florida's sunshine in winter, but in summer they have about as much at home. The greatest regional contrast is seen in eastern Washington, where the winter is very cloudy while the summer is almost as sunny as it is in southern Arizona.

The final map, 8, shows the average number of days per year of dense fog (based on the map in the 1941 Yearbook). It is seen that along the Pacific Coast twenty to fifty days have dense fog, but that in a broad western belt and in southern Florida fewer than five days a year have fog. The foggiest part of the East is Cape Cod, averaging more than sixty foggy days a year, but part of the Appalachians are almost as foggy.

The influence of the Great Lakes on the amount of fog is interesting. The area to the south and southeast of the Great Lakes has little fog, although it has relatively little winter sunshine (map 6). Fogginess is greatest for this general region, according to this map, to the west of Lake Michigan and Lake Superior. Another interesting detail shown is the greater fogginess along the lower Ohio River Valley and the Mississippi River Valley above the mouth of the Ohio. The Ozarks and the Black Hills also have evident influences, just as do the Appalachians, but effects of western mountain ranges are not evident. This suggests that the larger western valleys, in which most of the western Weather Bureau stations are situated, normally are too dry for fog. However, various lesser valleys at high elevations have much fog.

Several influences conspicuously affect the distribution of sunshine and cloudiness. Increased distance from the equator affects the length of day and the average temperature. In the north the relatively long summer days give more hours of summer sunshine but, conversely, their shorter winter days mean relatively fewer sunny hours. As the capacity of air for moisture is doubled or halved with each change of eighteen degrees Fahrenheit in temperature, the higher average temperature of the South makes for more sunshine than in the North because of greater vaporization of the atmospheric moisture.




MAP 8. AVERAGE NUMBER OF DAYS OF DENSE FOG PER YEAR

As average temperatures decline sharply with increased altitude, there is a corresponding rapid decline in capacity for moisture, resulting in a general increase in cloudiness and fog in mountainous areas. Mountain cloudiness is also increased by convection. As the ocean and the Great Lakes are relatively warm in winter as compared with the nearby land, cloudiness and fog are greater over and near them, on the average, than inland. As cloudiness is a form of moisture, it declines on the average, with reduction in availability of moisture. Hence, between the ocean and the mountains there is more cloudiness than on the lee side of the mountains. This helps explain the relatively lesser cloudiness in the West. Much cloudiness is caused by convectional disturbances, the most conspicuous example of which is the thunderstorm. Hence, where there is sufficient moisture and air disturbance to yield thunderstorms, cloudiness is increased. As the relative coolness of the Great Lakes in summer interferes with the development of local convection and often weakens approaching thunderstorms, this condition helps make the lake region relatively sunnier in summer. Thus, although the lakes increase cloudiness during the cooler months, they reduce it in hot weather.

Although data on cloudiness at night is inadequate, it is known that the drier parts of the country which are relatively sunny by day are even more generally clear at night. This is because where the air is dry, escape of heat from the earth is rapid as the sun goes down. As a result, the local convectional currents which are required to keep the clouds suspended, die away. Then gravity draws the cloud particles down to warmer air levels where they evaporate. Very often in all parts of the country the clouds clear away as night approaches. This is least common in the humid regions where dew formation liberates much latent heat and thus retards the cooling of the lower air. It is most common where there is relatively little moisture in the lower air.

Another contrast in cloudiness not shown by these maps is in the density of the cloud cover. In the drier regions the clouds are often thin while in the cloudier East and Pacific coastal areas clouds are often so thick as to be "leaden." Indeed, in these cloudier regions many thinly clouded days are recorded as clear by the Weather Bureau's sensitive photographic instruments, which continue to operate. However, on such days high thin cloud may cut out a considerable fraction of the ultraviolet light.

For some time to come "Science on the March" will be the experimental section of *The Scientific Monthly;* that is, we will experiment with it as to form and contents. We have a definite objective for "Science on the March"; we wish to show a panorama of the advancing fronts of science in such a way that a scientist on one front may get an idea of the action on other fronts and anyone interested may get a bird's eye view of the whole. If we could sit, like Zeus on Olympus, and see and understand all the diverse activities of science, we could approach our objective immediately; but we are subject to human limitations and also to restrictions imposed by the war on the dissemination of scientific information. So at present we shall have to present a peep-show instead of a panorama. The more information we get from the officers at the various fronts about the progress of their units, the more nearly shall we be able to present the desired panorama.—Eds.

### FOOD

Throughout the world the great problem now is how to grow more food with less labor and materials. This involves related problems on the kinds of food that should be produced so as to get the greatest nutritive value with the least expenditure of time and effort. Then come the problems of food protection, preservation, and distribution.

Research on food problems must now be devoted largely to answering pressing questions, utilizing so far as possible the results of previous research and doing only the kind of experimental work that tells us "what" and "how," but not "why." For example, the study of the conversion of solar energy into food by the green plant must coast while we find out how to serve soy beans to replace meat. Practical short-term research on food thrives under organization and cooperation among different specialists: chemists, agronomists, plant pathologists, entomologists, engineers, and so on. Thus we find the United States Department of Agriculture bringing together under the new Agricultural Research Administration most of the research bureaus of the Department, so that during the war period the broad practical problems can be more readily recognized and different specialists can be brought together to solve them. It is to be hoped that the more individualistic, long-term research problems will not be forgotten and will be given free rein after the war.

*Corn.* One way to get more food without increase in labor is to grow plants or raise animals that are inherently more productive of foodstuffs than those previously employed, or to grow a higher percentage of the better yielding varieties than was done before. For example, by growing hybrid corn, which nearly always outyields the open-pollinated varieties, six bushels of corn may be obtained where five were produced before. According to the Department of Agriculture, the practice of planting hybrid corn has expanded tremendously during the war. It is estimated that in the year 1942 about 630 million bushels of corn represented the bonus from the use of hybrid seed. Present research must deal with the problems of production of hybrid seed. What combinations of parent corn give the best seed for particular areas?

But that is not all. If disease or insects should take a large proportion of the crop, it will have been to no avail to have used an inherently high-yielding hybrid. Hybrids differ in their susceptibility to disease and insect attack. So the corn breeders work with plant pathologists and entomologists to develop hybrids that not only have the desired agronomic characteristics but also are highly resistant to the pests that might attack them. In northwestern Ohio, where the European corn borer has been prevalent, it would no longer be possible to grow corn commercially, if borer-resistant hybrids had not been developed. With the spread of the borer westward, Indiana and Illinois must revise their corn hybrids to meet the threat of this pest from Europe.

After corn is grown and harvested it must be stored for a time. In the granaries, weevils may attack it. To keep these pests under control it is necessary to gas the insects.

This is done by pouring or sprinkling upon the surface of the grain a volatile liquid which will trickle down among the kernels, evaporate, and pervade the whole mass with vapor toxic to the insects. The important ingredient of one new mixture is the same substance that is used for delousing soldiers' clothing. Another promising liquid makes the eyes water, but it reaches the bugs. Still another is a liquid that is used primarily in the production of one of the synthetic rubbers.

*Milk.* What is true of corn is in part true of cows. It is desirable to increase milk production because milk is a protective food which in many areas can be produced more efficiently than meat. We can get more milk without having more cows by replacing low producers with high producers. As the science of plant breeding leads to a greater yield of corn, so the science of animal breeding can increase milk production. According to the Department of Agriculture the average production of the dairy cows of the United States is 4,700 pounds of milk per year. The more select cows of the Dairy Herd Improvement Associations yield almost twice as much on the average. Thus the possibility of great improvement in the general average of milk production is obvious. Research in animal breeding has shown that it can be brought about by the use of proved bulls for propagation of dairy herds. The inheritance of a good bull can be greatly extended by the use of artificial insemination.

Reports on some aspects of the British attack on the problem of milk production, described below, are condensed from a summary by Professor John Hammond, F.R.S., physiologist of the Animal Nutrition Institute, University of Cambridge, and Fellow of Downing College.

The marked variation in seasonal production of milk in England has made it necessary to limit its consumption to an average of two pints per week per person during the late autumn and winter months. This seasonal shortage occurs because in winter many heifers and young cows do not go through the physiological cycle necessary for becoming pregnant. Injections of stilboestrol, a synthetic sex hormone, was suggested as a remedy but it proved to be ineffective.

On the other hand, injections of preparations of horse anterior pituitary gland or pregnant mare serum hormone (P.M.S.) have been shown to be very effective. Since supplies of these substances came mainly from France, Denmark, and Holland, steps had to be taken to obtain local supplies.

Large numbers of small wild ponies, in which the concentration of P.M.S. hormone is higher than in larger horses, were available in Wales and the New Forest in Hampshire, but, as the dates of service were unknown, an accurate method of determining the stage of pregnancy was required. The method of rectal palpation of the uterus was satisfactory, and supplies of serum were collected and prepared for use.

The effects of P.M.S. hormone on a cow depended on the stage of the physiological cycle of the animal at the times of the injection. When an injection of P.M.S. hormone was made in early or mid-cycle, no ovulation occurred. If an injection was made towards the end of the cycle, several follicles ripened and all ovulated together. By adjusting the time and dose, twin and triplet calves have been obtained, but the frequency of sterile female calves (freemartins) and males, which are not wanted by the dairy industry, is thereby increased. For the beef industry, however, it would be desirable to get as many sound offspring per cow as possible. Therefore injection of P.M.S. hormone may become commercial practice in England when the supply of feeding-stuffs for beef cattle again becomes normal.

Somewhat similar results have been obtained with sheep, but goats, however, can be caused to become pregnant outside of the normal mating period by one injection of P.M.S. hormone. Such injections have been found useful to increase the winter milk supply. Maiden goats can be brought into milk within the space of a few weeks by treatment with a cheap synthetic sex hormone, such as stilboestrol.

F.L.C.

### SYNTHETIC SEX HORMONES

Substances that influence the reproductive cycle in animals are known as sex hormones or oestrogens. According to John Harley-Mason of Cambridge University, England,

they are secreted by the anterior lobe of the pituitary gland (gonadotrophic hormones) and by the sex glands themselves. Male sex glands secrete testosterone and oestrone, and female glands produce oestradiol.

The gonadotrophic hormones are, as it were, the prime movers; passing from the pituitary into the bloodstream, they cause the gonads to produce their respective secretions. If these hormones and the hormones of the sex glands could be made in the laboratory, the way would be cleared for treatment of reproductive disorders in man and animals, and for modification of the reproductive cycle of animals to suit the needs of man. Much chemical research has been done in England and other countries on the determination of the molecular structure of natural sex hormones and on the building of identical or similar synthetic molecules. The structures of the gonadotrophic hormones are still unknown, but those of some of the sex gland hormones are now understood and oestrone has been synthesized.

Since the synthesis of sex gland hormones is a matter of great difficulty, two British organic chemists have been working on syntheses of compounds that have some similarity to the known structure of the female hormone, oestradiol, hoping to produce some substances that will have the same physiological effect as oestradiol and at the same time will be commercially feasible to produce.

Injecting their synthetic compounds into female mice and observing whether proliferation of the cells lining the vagina occurred, they found that one compound, which is called stilboestrol, had almost the same effect as the natural oestradiol. Stilboestrol, the full chemical name of which is 4:4′ dihydroxydiethylstilbene, can be quite readily synthesized in five stages from easily available materials.

Application of stilboestrol for increasing milk production in goats was noted above. This compound and a similar one, called hexoestrol, are now widely used clinically in sexual disorders of women and, according to Harley-Mason, have proved highly successful.

A derivative of stilboestrol, known as diethylstilboestrol, also originated in England. According to the United States National Cancer Institute, diethylstilboestrol may be useful for treatment of cancer of the prostate gland. Since experiments so far made with it have not always cured the disease nor even given temporary relief from pain and other symptoms, it would be premature to say that diethylstilboestrol is the answer to this problem.

F.L.C.

## THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE

Science marches on many fronts—in the study or the laboratory of the recluse, in the shelter of university halls, in the industrial laboratory, in the association of scholars as a school, an institute or a foundation. Medical science in America has never marched with higher purposes or greater strides than at The Johns Hopkins University School of Medicine, which has recently celebrated the fiftieth anniversary of its founding.

The Johns Hopkins University opened its doors to students of the arts and sciences in 1876, and the doors to the School of Medicine, in 1893. In the establishment of the university, and of the school of medicine as well, a new note was struck in American education and medical science. The whole institution was dedicated to research and scholarship on the highest possible plane; it was a place where the most promising young scientists would work under the most eminent scholars. The standards set by this institution during the first twenty years of its existence transformed the ideals for graduate schools in American universities.

The Johns Hopkins University School of Medicine was not the result of an inspiration speedily executed. It was contemplated from the opening of the University in 1876; the first definite steps toward the organization of a medical faculty were taken by President Daniel C. Gilman in 1884, and the University Hospital was opened in 1889, but the School of Medicine was not formally opened until six years later. In this long interval a department of chemistry was established under Ira Remsen; William H. Howell was appointed Professor of Biology; and William H. Welch, Professor of Pathology, began to organize broad courses in bacteriology, pathology and related fields. Preparatory to

opening the School of Medicine in 1893, Dr. Welch gathered around him such men as William T. Councilman, Franklin P. Mall, Simon Flexner, William Osler, Howard A. Kelly, and John J. Abel and recalled William H. Howell from Harvard. These are great names in American Science. Councilman, Mall, Flexner, Abel, and Howell were members of the National Academy of Sciences; Welch was its president during 1913–1917. Welch, Flexner, and Abel were elected to the presidency of the American Association for the Advancement of Science.

For the first time in American medical education all professors conducting proclinical courses were devoting their "entire time and strength," to use President Gilman's words, to their work as scientists. In other institutions courses in medicine were given almost entirely by practicing physicians. The new methods were later extended to the major clinical departments. This innovation at The Johns Hopkins University School of Medicine spread until it revolutionized medical education in this country. As early as 1902, only seven years after the School of Medicine opened its doors to students, Charles W. Eliot, President of Harvard University, speaking at ceremonies on the retirement of President Gilman, said:

> The twenty-five years just past are the most extraordinary twenty-five years in the whole history of our race. Nothing is done as it was done twenty-five years ago; the whole social and industrial organization of our country has changed, but among all the changes there is none greater than that wrought in the development of medical teaching and research; and these men whom you, sir, summoned here have led the way. . . . Among the achievements of Johns Hopkins University in the last twenty-five years, let this improvement of medical teaching be counted as one of superb beneficence.

Measured by dry statistics, The Johns Hopkins University School of Medicine has given the degree of Doctor of Medicine to 2,918 men and 361 women. This is indeed a considerable army of medical men and women, but they have not been an army of privates keeping weary steps to beating drums. On the whole they have been high officers, moved by more varied and richer tones, who have led the medical forces of a continent to unexpected heights. The effects of the wisdom and the pursuit of the high ideals of Gilman and Welch and their many associates today reach directly and indirectly not only throughout our land but into all of our far-flung battlefronts.

F.R.M.

## ROACHES

The prevalent method for wiping out an infestation of German roaches is to distribute a powdered insecticide in or near the cracks in rooms inhabited by these pests. A suitable powder properly applied will exterminate the insects in a few days, but powder deposits are untidy. Moreover, one of the preferred ingredients is temporarily difficult to obtain and the other is thought to be a menace to health when used in kitchens where the little dark-brown roaches are most numerous.

A neater and safer, but slower, method of roach control, was recently demonstrated by the inventor. For his demonstration he chose an infested kitchen. He filled ordinary test tubes with a weak solution of boric acid in water, plugged the tubes with absorbent wads, and distributed them inconspicuously in the kitchen. In about three days dead roaches were seen on the floor and at intervals for several days thereafter bodies of additional casualties were swept up until the kitchen was practically roach free. In principle: the roaches must drink water; unable to distinguish boric acid solution from tap water, they imbibe the former freely from the wet plugs of the test tubes. And so they meet an unnatural but timely end.

C. S. Barnhart

# BOOK REVIEWS

## MAN AND SOCIETY[1]

THE book consists, as explained in the subtitle, of "observations and reflections on man's nature, development and destiny." Its contents are presented in three parts, the first of which deals with the human species, its subdivisions and evolution; the second with individual development and heredity; and the third with a general philosophic discourse on a multitude of subjects which lie close to the heart of anyone who ever wondered about man and society. The book is written in a smooth, readable style and is apparently intended for the average nonscientific reader.

Professor Conklin is well known to many sections of the reading public. His scientific work in embryology occupies an important place in the development of American science, and his long career as professor at Princeton University has earned for him a worthy niche in the teaching of science. Aside from this, Professor Conklin has performed valuable service as president of the American Philosophical Society and has been useful in inspiring many scientists with respect for and even interest in social and philosophical problems, an inspiration badly needed in an age which extolled technical specialization and regarded with suspicion all concern with cultural and philosophical questions.

And yet, in spite of the author's record, the book is far from being satisfactory and suffers from many defects common to the efforts of many biologists who venture to write on the subject of what man is. To begin with, biologists seldom pay adequate tribute to anthropological findings. Stressing as they do the biological aspects of *Homo sapiens*, they emerge with biological material which is very interesting but hardly relevant to man's uniqueness. Few scientists who have devoted much thought and research to this question can fail to reach the conclusion that the distinctly human aspects of man can be described far more stimulatingly and soundly by anthropological data of culture patterns, their origin, diversity, spread, and disappearance, than by a study of embryology or even genetics. Yet few biologists have shown awareness of this point and most continue to talk of man in terms of the zoological sciences.

As a result of such oversight, when philosophically minded writers on biology come to discuss, as does Professor Conklin in the latter part of this volume, the question of human values, religion, the role of tradition, humanitarianism, militarism, racism, or escapism, all they have to offer is personal judgments eked out of subjectivity and possessing no roots in evidence even of a controversial nature. To add to the futility of such intellectual ruminations, the discussions are usually repetitions of what has been heard hundreds of times before and contain no new stimulation or challenge.

Most of the philosophical problems raised in *Man, Real and Ideal* are stale. One may venture to say that few of them will seem new to any reader, regardless of how average he may be and how interested he may be in reading books with a title such as this one. Even the subject of the meaning of religion to man is handled with a timidity which is reminiscent of the last decades of the nineteenth century when people who arrogated to themselves the label of the vanguard of progress declared faith to be the "opium of the people." Surely anthropology and the history of science and ideas in our own culture have much to say on this subject and reach different conclusions. The evidence for or against the validity of this slogan, inscribed on the walls of the Red Square in Moscow in the early days of enthusiasm, can be weighed in the light of historic and social data requiring no apologies or hedging.

Even from a strictly biological angle it is possible to write a general book on man and bring out some salient scientific problems which are relevant to our understanding of the subject and which stimulate the mind. Yet from this point of view as well, *Man, Real and Ideal* can hardly be considered suc-

[1] *Man, Real and Ideal.* Edwin Grant Conklin. 264 pp. 1943. $2.50. Charles Scribner's Sons.

cessful. The mystery of development which it presents sketchily is not sufficiently linked to human conduct to make it stimulating. The physiology of sensation, a far greater and more basic mystery so far as human behavior is concerned, is untouched. Evolution is discussed, but in terms of orthodox natural selection without taking cognizance of the major difficulties it is still confronted by and the newer experiments and ideas bearing on its limitations and possibilities.

As a result of these omissions, the book makes for smooth but superficial reading. It is difficult to see how the reader can carry away even one stirring thought on the subject of man which would make him feel that he has learned anything. One cannot disagree with Professor Conklin's ideas, his social values, or judgments. The book radiates a humanitarian and democratic social philosophy, a broadmindedness often lacking in such subjective accounts. Consequently there are no jarring and impassioned falsehoods, no perversions of truth because of fanaticism or over-enthusiasm. But these virtues are not sufficient to cover its inadequacy in substance.

MARK GRAUBARD

## BIOLOGY OF THE ITCH MITE*

THIS is a timely volume on the itch mite of man, by an author who has contributed much to our knowledge of this obnoxious parasite. Beginning with a consideration of the mites in general, the author then reviews the very early literature on the itch mite, starting with the seventeenth century. In so doing he gives reproductions of many figures published by the early workers, some of which are very quaint, even fantastic.

In the latter part of the volume the reader finds an extended treatment of our modern knowledge of the biology and anatomy of this mite, which, surprisingly, is referred to as *Acarus scabiei*. This is done notwithstanding the fact that in opinion 113, of the International Commission on Zoological Nomenclature, the time honored generic name of *Sarcoptes* was declared the proper one for *scabiei*.

Studies of the biology of the different forms of *Sarcoptes* have revealed a very interesting picture from the standpoint of taxonomy and evolution. All the forms of *Sarcoptes* which occur on man and domestic animals are anatomically so nearly alike that the slight differences between them, if and when present, are almost completely concealed by individual variations. Yet each of these forms is to a certain degree specific in its host relationship. The situation is very similar to that of geographical raciation, where the morphological differentiation is but slightly indicated. Possibly the term "host raciation" could be applied with propriety to it. The method of attack of the itch mite of man is very different from that of any other mite which attacks him in that the female tunnels under the surface of the skin. This is in sharp contrast to the method of attack by chiggers. They do not penetrate the skin but attach themselves to it by means of their chelicerae, in the manner of a tick.

Although no bibliography accompanies the text of this book, many footnote references are given to the literature cited.

H. E. EWING

* *Biology of Acarus Scabiei.* Reuben Friedman. Illustrated. 183 pp. 1943. $3.00. Froben Press.

## MICROBIOLOGY FOR NURSES*

WITH the creation of the United States Cadet Nurse Corps by Congress near the close of the last session it is only natural to find a marked increase in the number of textbooks in the field of nursing: new books and revised editions. This textbook belongs under the latter designation, being the third edition of a book enjoying a rather wide adoption.

The material covered is divided into two parts: first, the general principles of infection, resistance, and disinfection; second, microorganisms of medical importance. In the preface the author indicates certain features which have been retained or introduced for a specific purpose. One of these is the practice of indicating in the body of the text the derivation of technical terms. This is of undoubted help to the student, although it is well known that the derivation of a word does not necessarily convey its present meaning. An extension of this treatment to the

* *Microbiology. A Textbook for Nurses.* Royall M. Calder. Third Edition. Illustrated. 317 pp. $2.50. 1943. W. B. Saunders Company.

terms of pathology as well as those of microbiology would be of further use, bearing in mind that in most instances the students have just finished high school.

The discussion of the hypersensitive state, including anaphylaxis and serum sickness, in the chapter "Mechanisms of Bacterial Pathogenicity" is distinctly out of place but, unfortunately, this topic is nowhere given adequate attention. The nonspecific defensive mechanisms of the body are very briefly treated. Surely inflammation should be considered among them, together with the activity of the fixed phagocytes of the tissues. Phagocytosis is taken up only as an introduction to the descriptions of the opsonins. In the discussion of the antigen-antibody complex and its application to skin tests, the general statement that "whenever antigen and antibody come into contact with each other in the presence of living body cells, damage is done," is immediately contradicted by the explanation of the Schick and Dick tests. The chapters on the destruction of bacteria are clear and well planned. The discussion of the use of steam under pressure, however, is inadequate. The erroneous impression that "15 pounds pressure for fifteen minutes" are sufficient for sterilization can hardly be avoided. Under "intermittent heating," no mention is made of the fact that the materials being treated must be able to support growth if spores are to develop into vegetative cells during incubation. The author's insistence on the use of tincture of iodine, and not alcohol alone, for skin disinfection, and of cresol for the disinfection of thermometers is to be highly commended.

The common and important pathogens have been included in the second part of the book. In each chapter, the special nursing problems incident to the disease in question are listed. The segregation of the venereal diseases in a separate chapter is open to some question. If this is done, to be consistent the respiratory as well as other types of disease should be classified similarly. The discussion of food poisoning seems out of place in the chapter on Clostridia.

There are a number of errors in the book, of which the following will suffice as an example. Surgical removal of the infected gall bladder never "sterilizes" the intestinal tract. Better integration of clinical and pathological findings with bacteriological data would prevent the impression given on page 215 that laboratory tests constitute the final diagnosis of such diseases as syphilis.

The book is exceptionally well printed, well bound and of a convenient size.

MALCOLM H. SOULE

## ANIMALS OF THE ROCKIES*

A busy twenty-two years among the large game of the Western United States gives a forest ranger, who liked his job and did it, background for a most engaging book.

The author took every advantage of his opportunities to observe these creatures and he knows how to tell about them. In thirty-five chapters the reader meets personally bears, comic and terrible; elk, single and in herds; deer, antelope, mountain sheep and goats.

He encounters bankers and buffaloes, catches poachers, doctors sick wild deer, finds a lost herd of thousands of antelope.

This is a spendid book, replete with intimate facts about the animals and told in a manner that makes one want to keep on reading.

The photographs taken by the author are a fitting accompaniment to the tales.

WILLIAM MANN

* *Wild Animals of the Rockies—Adventures of a Forest Ranger.* William Marshall Rush. Illustrated. ix + 296 pp. 1942. Harper & Brothers.

THE SCIENTIFIC MONTHLY

FEBRUARY, 1944

# SCIENTISTS IN WARTIME

By GEORGE A. LUNDBERG

WHAT should scientists do in wartime? In general, and as far as possible, they should go about their business as scientists. I agree with President Hutchins' recent statement to faculty and trustees of the University of Chicago:

> . . . I believe that anybody who is good enough to be a member of this faculty is too good to be expended in Washington or the Army. I do not deny that there are many special cases—the cases of men with peculiar qualifications for specific positions which only they can fill. Such men we must surrender for the duration. But that restlessness which occasionally afflicts us all, that feeling that we are not doing anything very important and that we ought to be able seamen, corporals, or clerks in the Capital must, I am afraid, be traced to the low esteem in which our civilization has held the life of the mind, an esteem so low that even those who have committed themselves to that life must sometimes wonder whether they have not made a mistake. A university is a place where people think. Thinking is difficult at any time, and especially amid the distractions of war. But can we actually believe that thinking is not important to winning a war? If a member of this faculty is offered a post in the public service in which he can think to better purpose than he can here, he should accept it. If, as is far more likely, he has some chance to think here and none in the public service, he should stay here and try to think harder than ever. It is his patriotic duty to resist as long as he can the superficial attractiveness of what is called "doing something about the war" and to throw himself with grim determination into the essential task he was appointed to perform.

This statement contains the necessary reservations to cover the many persons, including the author, who have temporarily served the government from time to time, both in times of war and in times of domestic crises. Frequently the government job is similar to the work one is already doing. It may even afford unique opportunity to advance the work to which one is regularly devoted. Such work is no desertion of one's principal job. As for those who are not primarily interested in the advancement of science, they would perform a valuable service by vacating jobs in the fields of science. Again, other duties sometimes take priority over personal preferences and over the advancement of science. Every scientist devotes time to family and community affairs which he might often prefer to devote to science. In the last analysis the community supports all scientific activity, and may therefore sometimes reasonably demand the scientist's services in fields far removed from his special interest.

The general position taken above is, therefore, no reflection upon those who through choice or compulsion have entered either the military or the civil service. Indeed, it will probably be regarded as somewhat amusing that I should even take the trouble to make such a reservation. The temper of the times rather suggests that all who are *not* in government service need some kind of defense or explanation. For this attitude, Hutchins' statement is a healthy corrective. Let us consider some of the implications of this view.

## I

I have suggested above that the scientist sometimes may find his duties as a citizen conflicting with his scientific tasks. This fact is likely to become apparent to all scientists, especially in wartime. In this situation it is important for the scientist to distinguish clearly between his role as a scientist and his role as a citizen. Strange to say, even some social scientists question whether such a separation is possible. Yet it is about as obvious as the fact that an actor can play different roles on the stage, or that a man can

play both baseball and bridge without developing a schizoid personality. All that is necessary is to be fully aware of what part or what game one is playing and of the rules governing each. It is painfully obvious that human and community activities at present are not conducted on a strictly scientific basis. All scientists, as members of the community, must reconcile themselves to playing the social game according to the commonly accepted rules. As I shall argue later, the scientist, like any other citizen, should do his utmost to change the rules if he feels like it, but, while doing so, he must conform in general to the accepted rules or he will find his chance to do really effective work of any kind seriously curtailed. His role as citizen permits and, indeed, compels him to play the parts assigned to him in the life of the community in common with other citizens. As a citizen, also, the scientist may indulge his likes and dislikes by campaigning for this and against that, without giving any other explanation than that he simply likes one program and dislikes the other He may also offer whatever rationalizations or reasons he wishes in justification of his action, without inquiring into their scientific validity.

The role of the scientist, on the other hand, calls for the observance of very different principles. The scientist must divest himself as nearly as possible of all preconceived conclusions, except those all-important tentative formulations called hypotheses. The rules of the scientific game are rigorously specified. The very first rule is not to trust our unchecked, uncorroborated, and unaided senses. Thus, we use tested instruments for this purpose and, in addition, require that other scientists shall check both our observations and conclusions. In the social sciences, these rules have been quite carefully elaborated with special reference to this subject matter. An elementary principle of historical and other social research, for example, is to be cautious about accepting personal testimony; to check the possible bias of the reporter; to determine the representativeness of a report which is itself above suspicion; and so forth. To what extent are these principles observed in wartime?

Instead of going into the whole subject of the unbelievable gullibility of many scientists, as well as of other people in times of war, I shall ask only one question: How much of the currently accepted information about certain enemy ideologies and practices rests chiefly upon the testimony of displaced politicians, refugee scholars, and others who have suffered personal misfortune and injustice at the hands of the regimes in question? I do not question the personal integrity of these reporters. I only ask whether their testimony in a court of law or in science could be regarded as unbiased. I do not question their misfortunes. I have no doubt the facts are bad enough. To be sure, there is much corroboration—but by whom? By others with the same bias. I merely ask whether much of the material mentioned can stand the test of scientific scrutiny.

Time alone, perhaps, will provide both the possibility of scientific checking and the necessary perspective for sound factual appraisal. My point is that the prestige of scientists is not increased by their tendency alternately to ride the bandwagon and then, after the parade is over, to appear conspicuously in the ranks of the debunkers. As scientists, they never should be victims at least of the more traditional types of bunk.

Closely related to mere objectivity of observation are considerations of perspective and the representativeness of data which are otherwise above reproach. Neglect of this principle is the besetting sin of the journalist, who in our time frequently passes for a social scientist. The public, in fact, attaches to the pronouncements of journalists the type of significance which actually should attach only to the pronouncements of scientists. The journalist's trump in an argument regarding fact is always some appeal to dramatic incidents such as, "If you had seen the refugees leaving Paris, . . ."; "If you had seen this murder, . . ." If one inquires as to the representativeness of this incident, the prevalence of an injustice, and so on, the scornful answer is usually, "What difference does it make? Aren't you against wrong and evil although it occurs only in a single case?" The answer is that for scientific purposes it does make a difference. There is probably no crime or atrocity committed in one nation which cannot be duplicated in others. The degree and frequency of phe-

nomena are important for scientists but not necessarily for artists, and perhaps not even for some types of historians.

Likewise, the concept of probability is all-important in science. In these days of romantic talk about freedom from want and fear, it should be recognized that such "freedom" is only partially attainable and that it is always a relative matter. To think otherwise is self-delusion. When nations strive for "security," they should consider what state of affairs would obtain if all nations took the same view of *their* security. For example, if we require a line of impregnable bases flung across the Pacific, as has recently been asserted, other nations might reasonably consider themselves entitled to Nantucket, Cuba, Hawaii, and other such sites for bases off our coasts to insure *their* "security."

After the scientist has once secured his data, the rules for their manipulation are again rigorously specified. We are expected to follow these rules and to be just as cheerful if our hypotheses are disproved as if they are proved. Finally, we are compelled to agree that these findings are neither good nor bad in themselves; they may be used with equal effectiveness for constructive or destructive purposes. We even have to confess, I think, that no matter how indubitable is the conclusion of a scientific study, there is nothing in the scientific process, by which we arrived at a specific conclusion, to tell us what should be done with it.

Science only provides a car and a chauffeur for us. It does not directly, as science, tell us where to drive. The car and the chauffeur will take us with equal efficiency into the ditch, over the precipice, against a stone wall, or into the highlands of age-long human aspirations. If we agree on our destination, the driver should be able to take us there by any one of a number of possible routes, the costs and conditions of each of which the scientists should be able to specify. When these alternatives have been made clear, it is also a proper function of the scientist to devise the quickest and most reliable instrument for detecting the wishes of his passengers. Except in his capacity as one of the passengers, the scientist who serves as navigator and chauffeur has no scientific privilege or duty to tell the rest of the passengers what they should want. Neither physical nor social science can answer this question. Confusion on this point is the main reason for the common delusion that the social sciences, at least, must make value judgments of this kind.

It does not follow, of course, that science by virtue of its true function, as outlined above, may not be of the utmost importance in helping people to decide intelligently what they want. As a matter of fact, the broad general wants of people are perhaps everywhere highly uniform—for example, a certain amount of physical and social security and some fun. It is disagreement over the means to achieve these ends, as represented by fantastic ideologies, that results in conflict and chaos. In proportion as a science is well developed, it can describe with accuracy *the consequences* of a variety of widely disparate programs of action. These consequences, if reliably predicted, will strongly influence what people will desire. But it remains a fact that science as a predictor of consequences is only *one* of the numerous influences that determine an individual's desires and his consequent behavior.

When social science develops and secures recognition of its authority, it is almost sure to become a major influence both in defining and satisfying men's desires. This certainly is the case with desires that are increasingly defined, as well as realized, through the agency of physical and biological science. By charting reliably the remote, as well as the immediate, consequences of the various possible courses of action, men's wants will be modified accordingly. In this way, science and scientists might be major influences in *determining* value judgments. This is especially true of the social sciences as regards the questions at present in the foreground of public interest. When the social sciences attain maturity and thus gain public respect, we shall no longer waste our energies in following the vain hopes of early and permanent salvation proffered by various ideologies which today seduce many social and other scientists, as well as the masses of men, from more fruitful activities.

## II

I have spoken of the scientist's obligation

to stay on the job and keep clear in his own mind, as well as in the minds of others, the difference between his scientific and his community obligations. Closely related to these requirements is his obligation to conduct himself like a *scientist*. This is perhaps the most difficult of the social scientist's tasks in wartime. His own emotions, as well as the community expectations, tend to coerce the social scientist into two equally unfortunate positions. In the first place, the scientist will be tempted to find, regardless of the evidence, what he and the community wish to believe regarding important war questions. In the second place, both social and other scientists are likely to fail to distinguish clearly between their pronouncements as *citizens* of a *country* and their pronouncements as scientists who, in these roles, are citizens of no particular country. In the first case, they deceive both themselves and the public. In the second, they may deceive only the public. The public will assume that, just because a man is a recognized scientist, all his pronouncements are actual scientific conclusions.

This is why it becomes necessary to engage in wholesale debunking after the war is over. Now it can probably be shown that it is necessary for every nation, in order to carry on a fundamentally emotional activity like war, to engage in the systematic diffusion of propaganda which cannot correspond very closely to scientific fact. This may be justified in precisely the same way that we justify withholding bad news or telling a patient something less than the whole truth about his condition, in the interests of what is considered a more fundamental objective. If, however, the physician who does this is himself so interested in the patient's recovery as to believe what he tells the patient and then acts on his belief, we regard him as incompetent.

Consider the pronouncements of governments engaged in war. It is probably a psychological necessity for all nations at war to declare that their objective is complete victory over their enemies: that no agreement, appeasement, or compromise is possible. But social scientists, if they apply what they know is true of all social adjustments, are compelled at least to consider other conditions. A zoologist, writing in *The Scientific Monthly,* has recently put the matter bluntly. Speaking of the coming peace he says: "It will not rest upon compromise or compact." He admits that some kind of organization will be necessary, but scoffs at the idea that "to have effective world organization you must first educate the people and that will take generations . . . ; but it is no discredit to democratic principles to point out that the control of yellow fever and bubonic plague did not have to wait upon general education and popular demand. . . . For the control of war, as of pestilence, it will be necessary to educate administrative officers and representatives; then, of course, the farther the education of the people can be carried the better. . . . We are now confronted with war and the makers of wars, and the only proper action, whether one likes it or not, is to go just as far in annihilation, or in imposition of 'durance vile,' as is necessary to create . . . a greater distaste for war than some nations have thus far had. You *can* indict a people—*if* you can bomb them, and do not care to do it periodically."[1]

The above undoubtedly represents the simplest solution of the peace problem. It involves no troublesome peace conferences, no complicated treaties, no reparations, no danger of future trouble from the conquered. With sword and bomb, war will have been stamped out as yellow fever disappeared with the mosquito.

Offhand, I suppose, most social scientists would content themselves with pointing out that the implicit assumption in the above reasoning is that Germans and Japanese are carriers of war just as mosquitoes carry the germ of yellow fever. In view of the more elementary facts of history, no informed person will probably want to continue the discussion beyond this point. One peculiar detail should be noted, however, in the article containing the above prescription. The author makes it perfectly clear that this is a sound solution only if he himself and his group is on the exterminating side. From a strictly scientific viewpoint, the results, so far as the abolition of war is concerned, would be precisely as satisfactory if the other side did the exterminating. This suggests

[1] R. E. Coker, "What are the Fittest?", *The Scientific Monthly,* January 1943, pp. 69–70.

that there are other considerations more important even than stamping out war. There seem to be other considerations demanding attention even in the mind of this scientist, although he conveniently overlooks them or takes them for granted for the purpose of his argument. This is very frequently the case, as we shall see, when any scientist ventures into other fields than his own. We oversimplify and overlook conditions that are likely to be the most determining ones. Now the principal trouble with this particular solution as applied to social problems, namely, the extermination of all who oppose the would-be exterminator's ideas as to the proper solution, is that it is a game at which all parties can play. It is somewhat amusing, also, to hear the doctrine invoked by an American scientist in an article devoted to expressions of horror of war and a discussion of the fitness to survive of people who invoke this doctrine.

While the above case will probably be regarded as extreme and unrepresentative (I am not criticizing the article as a whole), the general sentiment is by no means unique. Witness the horror and condemnation with which the words "appeasement" and "compromise," as applied to the forthcoming peace settlement, are regarded in our most idealistic, moral, and respectable circles, including social scientists. Yet no fact is more generally recognized than that social groups, to the extent that they have abandoned mutual exterminative warfare, have substituted appeasement and compromise. They are, in fact, the social principles most commonly used in all social adjustments from the family to national and international relations.

Nor are appeasement and compromise resorted to only when physical violence has failed. No one could have desired a more complete military victory than that achieved by the Allies in the first World War. Yet the ink was hardly dry on the Versailles treaty before the machinery of appeasement and compromise was set in motion. It is no answer to say, "We shouldn't have done it." The fact is that the victors found themselves in a position where it appeared to be the sensible thing to do. More important than this single case is the singular fact that in all modern wars, at least, the victors have for some strange reason been unable or unwilling to exterminate whole nations. Even the invention of the modern bomber, to which our scientist friend so hopefully refers, has proved surprisingly ineffective in exterminating any considerable proportion of enemy populations.

At this point, the more emotionally inclined will demand to know, do I then advocate appeasement and compromise in the present war? It is pointless for me either to advocate it or oppose it. No matter who wins, appeasement and compromise will occur because there is, practically speaking, no alternative. The only subjects for profitable discussion are the details of the appeasement and compromise. Military events will doubtless determine these to some extent, although, if we may judge from the last war, not to the degree fondly hoped for by the victor. If those details are arranged carefully and with due regard for existing scientific knowledge, a relatively satisfactory peace and post-war world may be attained. If such knowledge is ignored, no league or other organization can succeed.

Is there any scientific knowledge which, if applied, would have rendered the Versailles settlement less absurd? Assuredly there is, and much of it even was called to the attention of the peacemakers. The peacemakers in turn may have known better than their actions indicate. They probably felt, and correctly, that public opinion would not tolerate a less vindictive or a more intelligent settlement. To win a war it is undoubtedly necessary to fabricate a grossly distorted picture of the world and especially of the enemy. This picture cannot be immediately erased when peace comes. Consequently, it is necessary to write a peace which corresponds not to the actual conditions that exist but to an illusion carefully built up during the course of the war. Such a peace again leads to war and thus perpetuates the vicious circle.

The scientist must reckon with this situation quite as realistically as with economic arrangements and the location of boundaries. That is, the distorted state of public opinion is an important factor in the peace negotiations. This may require the deliberate inclusion in the peace terms of enough vindictive

and irrational elements to make the settlement tolerable to the victors and not unbearable to the vanquished. This is the very essence of appeasement and compromise. It affords opportunity also for the social psychologist to devise symbolic rites of expiation and wish-fulfillment so that these war-stimulated needs may be satisfied as harmlessly as possible. To do this, the social scientist himself must maintain, during both war and peace, a scientific view of the social relations of nations. He must hew to the line as a scientist, whatever illusions he may wish to cherish as a citizen.

So much for the logic of appeasement and compromise. Let us examine another red rag which all patriotic bulls are supposed to attack with everything in them. I refer to the word *isolationism.*

Currently, the term *isolationism* is supposed to refer to a certain type of international policy, allegedly supported by a considerable section of opinion in this and other countries. What does the social scientist find when he examines the facts? The first thing he finds is that in modern western civilization there has been no such thing as political, geographical, or economic isolationism. The next thing the scientist finds is that even politically, and this is usually what the term means, the doctrine has been formally almost unanimously disavowed in this country for over a century. The Monroe Doctrine obviously constitutes such a disavowal, and we have shown no hesitation in making it good by force of arms.

To whom or what, then, exactly does this term apply? It is actually, of course, only an epithet. Isolationism has been used recently in this country to apply to the opponents of the present administration's foreign policy; that is, Foreign Policy No. 2, the one beginning in 1937, as contrasted with the previous Policy No. 1 which, in current terminology, must be designated as isolationist. I am not here concerned, fortunately, with the merits or demerits of either policy. Either one, pursued consistently, might have been defensible. I am concerned as a scientist at the moment only with an inquiry into the actual meaning of a category. Now it is true that, while none of the so-called isolationists contemplated any retrenchment in the Monroe Doctrine, they did oppose its extension as a political policy to the British Empire, Poland, China, and other places. As for economic and other international relations, these have always been pursued rather independently of the Doctrine anyway. That is, the so-called isolationists advocated the continued maintenance and adoption in other continents of political regionalism such as the Monroe Doctrine represents.

Only about a year after our entry into the war, it began to appear that this was what everybody had in mind. The Vice-President declared that "purely regional problems should be left in regional hands." "Pan-America," he says, "while concerned, should not have to be preoccupied with the problems of Europe." Subsequently, Mr. Churchill advocated the same idea in calling for a Council for Europe and a Council for Asia. It is true that Mr. Wallace in the same speech also came out for "supervision, or at least inspection of the school systems of Germany and Japan." Perhaps, on further thought, it will be decided that this had better be left to regional jurisdiction also, since we might not like the suggestions that Europe and Asia, respectively, might make regarding what we should teach in American schools.

It is true that there is much vague talk about some kind of world organization *in addition* to the regional Councils. But this organization will apparently not interfere in the regional political concerns of the Councils. This seems to be the upshot of the great excitement about isolationism. Parenthetically, this seems to me a relatively sensible approach to the world situation, though it leaves unanswered many nice questions raised by such pronouncements as the Four Freedoms and the Atlantic Charter. I suggest that it is the business of social scientists to examine the content and implications of these programs, especially with reference to their feasibility in view of "existing commitments," as the Charter blandly put it. By a responsible consideration of such problems, social scientists may contribute a great deal toward alleviating the shock, disappointment, frustration, and let-down, with their accompanying dangers, which tend to follow

in the wake of idealistic wars. Social scientists could also perform a valuable service by examining realistically the claims of every nation to be fighting a war for defense and survival; or by examining whether such terms as applied in modern warfare are not quite devoid of objective meaning.

I have introduced these views on some aspects of the current situation merely to illustrate what seems to me the type of problem that faces the social scientist if he wants to work as a scientist. If these questions are answered objectively, the answers may contribute considerably to a more rational determination of present and future social policy. If such questions are not objectively answerable among scientists, that merely reflects the unsatisfactory development of social science. Social scientists, as well as the physical and biological scientists, must go behind the more obvious and generally accepted appearance of things and identify them in all their superficial novelty as merely special cases of principles already understood. It is this point which interests me at present, not the illustrations I have used.

## III

That there is disagreement among so-called social scientists on such matters as I have discussed, and hundreds of others that might be mentioned, is perhaps the best evidence of the unsatisfactory development of these sciences. We do not have generally accepted and demonstrable generalizations, nor do we have adequate diagnostic power to place new occurrences promptly and surely into their proper categories and therefore to deal with them according to known principles or laws.

This raises the crucial question of whether social phenomena are indeed subject to scientific treatment. That question I have treated at length in other places and have no doubt of the affirmative answer. To those who think the answer is negative, and formal proof obviously cannot be forthcoming until after the fact, I can only say that we must proceed on the affirmative hypothesis or else stop claiming to be scientists. The *desirability* of a social science comparable in scope, precision, and application to the mature physical and biological sciences is rarely questioned. Are we likely to make progress toward this goal if we assume that a natural science of social phenomena is impossible?

It comes down to this: Shall we assume that man's social behavior, including all his thinking, knowing, and acting, is subject to study in the same framework as the rest of nature? Pierce, James, Dewey, and Bentley are the great names which, in direct line of advance from Darwin, have espoused the *theoretical* tenability of this view. They have examined man as an organism behaving in the world of his origin with *all* of his culture, knowledge, thoughts, and aspirations included. Who that examines both the theory and the data that already have been adduced to support this hypothesis can doubt that all social behavior can be understood within the framework of natural science? To deny it throws mankind forever back into the brutish abyss of the animistic and supernaturalistic conception of himself and the universe.

It is not necessary for my present purpose to go into any argument as to the possibility or probability that the social sciences can approach the exactness and applicability of the advanced physical and biological sciences. Only the future can answer that question. No matter how men may disagree on that issue, all social scientists seem to be agreed on one thing, namely, that there is room for improvement in our respective disciplines. There is also a fair amount of agreement as to the unquestionably feasible next steps. For example, we probably agree that social scientists have some responsibilities and standards which must be observed in their work which the artist, whether novelist, dramatist, journalist, or propagandist, is not obliged to observe, although he may otherwise often deal with very similar material.

Perhaps I can best summarize the point by an illustration. A distinguished political scientist of Cambridge University, writing a short time ago in *The New York Times Magazine* on "Europe's Portrait of Uncle Sam," makes the following revealing statement:

> The movies do give an impression of ease, of a social fluidity that may be false but is certainly seductive. I have read too many powerful American novels to assent readily to the thesis that, on the whole, life in America is easier and happier for the common man than in any of the European industrial countries, but were it not for those powerful novels I should assent

to this view, and most Europeans only know and believe what they see in the movies.

That is, while most people in Europe get their ideas about America from the movies, this great scholar is not so gullible. He checks on the reliability of the movies by reading novels. In short, if we really want to know how things are at the bottom of a rabbit hole, read a work by Lewis Carroll for the report of an eyewitness named Alice. Also, if you want to check the reliability with which the English novel portrays English life, visit the English movies.

Without claiming for a moment that this is a typical instance of the methods by which social scientists arrive at their conclusions, it does emphasize one of their principal faults, namely, the factual inadequacy of their reports on a purely expository level, even when intentional or unconscious bias is not present. I have already pointed out how personal bias resulting from misfortune or dramatic experiences may warp the judgment and distort the perspective of even able and well trained scholars. The inadequacy and non-representativeness of the data at the foundation of current social science generalizations is unquestionably a major and all-pervading fault of these sciences. Whatever differences of opinion may exist regarding the degree to which this fault can be corrected, probably we all can agree that improvement is necessary and possible. If we believe that there is a basic difference between the report of the social scientist and the journalist or the novelist, then we should strive to make that difference increasingly clear.

This is not to say that the novel *may* not be both factual and representative. We merely must remember that it is not an *obligation* for the novelist to be either; a good story need not be factual or typical; it has to be both in order to be a useful basis for scientific generalization. Nor can we judge factuality or representativeness merely by our own feelings that the tale "rings true." If we ourselves have an inadequate or a distorted notion of the facts and the perspective, then only a distorted image will "ring true." Whatever may be the ultimate possibilities of the social sciences, surely we can agree on the necessity not to mistake mere personal conviction for proof. Scientific methods are designed for this purpose. Generalization from inadequately tested and unrepresentative data is perhaps the most elementary type of error in science. Yet it is one of the commonest faults of the social sciences.

It is the fate of every science, in its early stages especially, to be trailed by bogus camp followers and quacks whose product is indistinguishable to the public eye from the real article. In the long run, only the superiority of science can win for it recognition over counterfeits. The social sciences will gain recognition in proportion as they develop the capacity to deliver the things that the public expects from science.

## IV

Finally, it is the business of social scientists to educate others to the idea that human affairs are subject to objective scientific study. This is perhaps more important than the mere imparting of a knowledge of subject matter and of technical methods. The masses of men today who do not know much about the technical details of the physical sciences, nevertheless have a rudimentary understanding of the assumptions and the methods of these sciences, as compared with the superstitions and animistic beliefs of other days. The masses of men today recognize the authority of these sciences and rely upon them for guidance. While the idea that human relations are subject to the same approach has been growing steadily since Darwin, at least, there is still widespread doubt as to the authority of the social sciences. We must admit that, in part, this public skepticism is justified because of the inadequate development of these disciplines. Much of the lack of respect for social science, however, is due to ignorance of the actual attainments and possibilities of these sciences. To the extent that this is true, we must strive for the wider diffusion of the idea that man's last, best hope is in the extension to human relations of the scientific methods that have been so conspicuously successful in solving our physical and biological problems.

The existence and validity of the social sciences must above all be impressed on other scientists. The public regards them as the authentic spokesmen of science, and when they express grave doubt, as they frequently

do, regarding the hope of a scientific approach to human affairs, these views are likely to carry great weight with the public, which is therefore inclined to look elsewhere for help. I shall give only a single recent illustration.

In his presidential address to the American Association for the Advancement of Science in December, 1942, Irving Langmuir made this statement:

> To avoid alternating periods of depression and prosperity economists propose to change our laws. They reason that such a change would eliminate the cause of the depressions. They endeavor to develop a science of economics by which sound solutions to such problems can be reached.
>
> I believe the field of application of science in such problems is extremely limited. A scientist has to define his problem and usually has to bring about simplified conditions for his experiments which exclude undesired factors. So the economist has to invent an "economic man" who always does the thing expected of him. No two economists would agree exactly upon the characteristics of this hypothetical man and any conclusions drawn as to his behavior are of doubtful application to actual cases involving human beings. There is no logical scientific method for determining just how one can formulate such a problem or what factors one must exclude. It really comes down to a matter of common sense or good judgment. All too often wishful thinking determines the formulation of the problem. Thus, even if scientifically logical processes are applied to the problem the results may have no greater validity than that of the good or bad judgment involved in the original assumptions.

From illustrations of this type, this physical chemist expresses further grave doubts about the utility of science in the field of social relations. He says:

> It is absurd to think that reason should be our guide in all cases. Reason is too slow and too difficult. We do not have the necessary data or we can not simplify our problem sufficiently to apply the methods of reasoning. What then must we do? Why not do what the human race has always done—use the abilities we have—use common sense, judgment and experience. We under-rate the importance of intuition.

He concludes with the vague suggestion that in human relations "morality and decency," being "a kind of summation of the wisdom and experience of our race," are perhaps our safest guides.

It is unnecessary to go into an extended analysis of these remarks. No one will quarrel with Dr. Langmuir when he points out that the formulation of problems and the decision as to what to include and what to exclude in a definition or a problem "comes down to a matter of common sense or good judgment." Nor will anyone disagree with him when he points out that "scientifically logical processes" applied to a problem may yield results of "no greater validity than that of the good or bad judgment involved in the original assumptions." Obviously these platitudes apply with equal force to physical problems. They are here put forward, however, as unique and more or less insuperable to the social sciences. When confronted with these and other staggering considerations of the same type as they appear in the social sphere, what does the distinguished Nobel Prize winner in chemistry advocate? "Why not do what the human race always has done," he says, ". . . use the abilities we have—use common sense, judgment and experience."

Again, certainly no one in any science will disagree with the advice as far as it goes. Certainly, even Dr. Langmuir can use only the abilities which he has, and on every level of science it is agreed that common sense, judgment, and experience are invaluable. The unfortunate suggestion of the statement, especially in its context, lies in its implication that this is *all* we should attempt to rely upon in the social sciences. This is directly giving aid and comfort to obscurantism, and directly suggests that the most we can hope for in the sphere of social knowledge is folklore, with all of its superstitions, its mysticism, and its error. To be sure, man has survived after a fashion even with this defective guidance. To be sure, morality and decency are based on the experience of the race as defectively observed, interpreted, and handed down. It is not necessary to deny an element of validity even in many primarily magical practices. It is grossly misleading, however, to fail to point out at the same time that it is only as science has subjected the elementary methods of common sense to its own rigorous discipline that the practices and the advice of old women, sages, and seers, heavily fortified by morality and decency, have been supplanted by modern medicine and technology.

Ludicrous as it may seem, one of the principal obstacles to the development of the so-

cial sciences is the attitude of *some* distinguished physical and biological scientists, especially of the older generation. Fortunately, the younger generation, as a result of some training in the social sciences and by virtue of a better knowledge of the nature of science, will be less of a handicap to the advancement of the social sciences. Indeed, the urgencies of the social situation may turn the attention of many physical scientists to a serious study of the problems of the social sciences. This is to be welcomed with the greatest enthusiasm. We desperately need men with the scientific ideals and technical proficiency so common in the other sciences. We have profited much from them in the past. Consider the contribution of Comte and Ward in sociology, Marshall in economics, Thurstone in psychology, and Boas in anthropology, to mention only a few. All of them were trained originally in the other sciences. Let us hope that many physical and biological scientists in the future will turn their attention seriously to the problems of the social sciences. Let us try to educate the rest to a broader conception of science than many of them now have.

## V

I have now reviewed what I believe to be some of the principal conditions for the advancement of the social sciences. They are conditions which to many people seem harsh and inhuman. They are conditions which demand a stern control of many laudable emotions and sentiments which have through the centuries beclouded and distorted man's judgment of human affairs. No one questions the necessity or desirability of the sentiments of love, hate, approval, and indignation in the attitudes of the members of a community. Nor does anyone question the right of the scientist as a member of a community to share these emotions both toward community affairs and toward the standards of his own science. Science merely requires that these sentiments must not be allowed to distort observations or to deflect the rigor of scientific reasoning.

We know how greatly wishful thinking has warped man's theories, observations, and reasoning about his world. Only in recent centuries has he imposed upon himself objective criteria in the form of instruments and rules of logic to check his conclusions, chiefly regarding the physical universe. He has often resented bitterly the conclusions forced upon him by these methods when they have conflicted with his traditional beliefs. It is not surprising, therefore, that he should be even more resentful of some scientific conclusions regarding social relations.

This resentment frequently finds expression in diatribes against the "materialism," "inhumanity," and lack of moral fervor that characterize science. Against this apparent callousness of science is invoked the importance in human affairs of vision and ideals. Here is alleged to be a conspicuous failing of science as applied to human affairs, whatever virtues it may possess in other matters. The feeling is so widely and sincerely held that it deserves sympathetic consideration.

It has been said that "where there is no vision, the people perish." Science certainly has no quarrel with this adage, for all scientific activity is a quest in pursuit of a vision, namely, the hypothesis which gives direction and meaning to scientific enterprise. No one knows better than the scientist, therefore, the importance of vision in human activity. The scientists and men in general know that a great deal depends upon the nature of the visions they elect to pursue. People who do not show a certain discrimination in the visions which they see and follow are in fact carted off to asylums to protect them and their fellow citizens from untimely and unseemly ends. In short, where there is irresponsible and fantastic "vision," the people are also likely to perish.

Perhaps it would be well for the great exponents of "vision" and "ideals" in human affairs to give more emphasis to this side of the matter than is customary. To be sure, the idea is implicit in most discussions of the subject. That is, when people advocate vision and ideals they usually mean desirable, attainable goals. Nevertheless, a more careful scrutiny of social ideals and visions is perhaps one of the crying needs of our time for pretty much the same reason that it has been found necessary to restrict or supervise the applied idealism of advertisers, patent medicine venders, faith healers, and stock salesmen. It is doubtless a shocking thought that

the visions for which men sometimes die and the ideals for which leaders are venerated should sometimes be indistinguishable from flagrant fraud and colossal ignorance. A sober survey of the history of idealism will nevertheless reveal such to be the case.

We must here distinguish sharply between those idealists who have specifically declared that the kingdoms they envision are definitely not of this world and those who equally specifically declare their programs to be for all men everywhere and in our time. Certainly no one objects to the dreams of seers and sages regarding the ultimate destiny and complete happiness of man. Nor do we contemplate depriving man of romantic literature, or of all of the satisfactions which indubitably derive from fable, myth, and story. There is no question that these imaginative realms greatly enrich life and influence conduct. For this reason, also, the somewhat indiscriminate deprecation of escapism is quite unwarranted. All that needs to be deplored is the inability to distinguish between fact and fable, the practical and the fantastic. Escape from the cares of the day has always been sought, has been anticipated with joy, and has refreshed the body and mind. Different people will find this escape in different ways. Some find it in mathematics and philosophy, some in music, some in poetry, and some at the movies of Buck Rogers' rocket trips to the moon. I have no objection even to the last mentioned, provided the beholder does not try to take off in his car on the way home. This is precisely the important qualification that must be insisted upon regarding all visions and ideals. Unbridled social idealism unbalanced by scientific criteria as to possibilities and cost is a social liability and in effect a type of fraud on the body politic.

Social scientists are at a considerable disadvantage today in competition with professional social idealists. Honest physicians were once at a similar disadvantage in relation to the snake oil practitioners. The latter promised quick and painless cures—no painstaking diagnosis or complicated course of treatment over a period of time was required. The offerings of social scientists today seem weak, uncertain, painful, and costly as compared with the proposals of the professional idealist whose lyrical sales talk clogs the airways, fills the press, and thunders from the platform. Science is not without its own ideals. But it has the decency to stipulate also the degree of probability of their attainment in given circumstances and periods of time.

The time will perhaps come when the irresponsible idealist will be regarded no more highly than other venders of bogus gold bricks. Today idealists go up and down the land with offerings that are as fraudulent as any patent medicine or snake oil that was ever retailed. Yet these are the respectable leaders of the day. It is true that the snake oil vender usually knew he was a fake, whereas many social idealists believe what they say. This, however, does not affect the truth or the frequently disastrous results of their respective offerings. Hitler's reported advice with respect to lying, namely that a big lie is believed more readily than a small one, seems to hold also for a certain type of social idealism. A ham-and-eggs program for California is not taken too seriously, but a similar program for the whole world may be widely praised in the name of idealism. Those who demand the specifications of these grandiose projects and a look at the balance sheet of estimated costs and probabilities of success are castigated as cynics and ignoble characters. Nevertheless, a decent respect for certain facts and principles now known by social scientists would greatly modify the nature of projects embarked upon today by the statesmen of all nations, to the great advantage of their constituents in every land.

The function and power of ideals in human affairs has nowhere been questioned. Indeed, this essay is itself idealistic. But we have neither advanced counsels of perfection nor advocated unattainable goals. There is, unfortunately, in science, as elsewhere, a type of idealism closely resembling that criticized above. It demands that social scientists present here and now formulations comparable in precision and predictive power to those of the advanced sciences. We have rather taken the position that in science and idealism half a loaf is better than loafing, and that the road of science is a long, rough road. Ideals we must have. Let us distinguish between ideals and illusions.

# THE JOURNEY, NOT THE GOAL*

By CURT STERN

COOPERATION in science has become one of the keynotes of our times. It is said to be of help in solving problems that surpass in extent the powers of work or the span of life of a single person, in combining the resources of various scientific disciplines, and in accelerating the tempo of scientific progress. Committees administer funds devoted to joint attacks on the riddles of cancer, radiation, and sex. Foundations map out coordinated programs upon which they then grant the smile of financial support. Heads of laboratories and individual investigators plan the course of group activities.

## I

It would be ridiculous to deny the usefulness, the desirability, and the necessity of scientific planning and teamwork. It is a cause for rejoicing that the cooperation of observatories can be enlisted to provide a more complete knowledge of the astronomical universe; or that the several hundred investigators who use the fruit fly in their study of heredity and who, although separated by thousands of miles, are enabled to consult each other's stock lists through the *Drosophila Information Service*. There is no doubt that the attainment of practical goals of research, as it is incorporated in the technical and medical structure of our civilization, has been due to planned collaboration of many workers. True it is also that many of the bridges which now join formerly separate fields, such as biology and chemistry, or physics and geology, had to be built by the joint efforts of helpers on both sides of the original gap.

Planning, even from the point of view of the individual, is a condition *sine qua non*. The selection of certain problems as worthy of study and the rejection of others involve a consideration and an intentional molding of the future of research. This is unavoidable to the investigator who seeks coordinated insight rather than an assemblage of unrelated facts. These statements are not contradicted by the proverbial experience that the most striking scientific developments generally have not been planned in advance, nor by the fact that many attempts at scientific foresight have not brought the hoped-for unity of results.

Important as they are, the obvious gains brought about by cooperation and planning have tended to obscure the danger of a great loss. The meaning of science is not exhausted by reference to its special attainments and goals. It surpasses its great tool, the scientific method, the weighing of rationally gathered evidence regardless of irrational prejudices, one's likes or dislikes. It even goes deeper than the search for the evasive "truth." One of the fundamental aspects of science is its lack of purpose. Like a leitmotif of the artist, one underlying theme of science is complete self-sufficiency, the exhaustive living in the moment, the self-forgetting abandonment to a determination, the source of which is wholly contained in the subject matter itself. This essence of art and of science may seem contradicted by another characteristic, the creative attitude, but do not mountains present different views from different angles? Yielding abandonment and willed creation both are elements within the artist and the scientist.

## II

Science, during the last one hundred or more years, has been in the dangerous position of a successful poet who started by composing songs of joy and sorrow to lighten the burden of his own soul only to find that they became best-sellers. He continues to appeal to the public's clamor for more and his annual output is large and satisfying, but though the product still shows clearly the stamp of its originator, the human ring of the first slender volume has only rarely been found again.

* The following thoughts were written down before the war. Whatever truth may be found in them will bear profession and defense at any time, and especially during the war.

Science as a profession has been a rather modern development. Many of the great men of the 17th and 18th centuries made their discoveries in the spare time left after their everyday occupations had earned them their living. Leeuwenhoek, the discoverer of a hitherto unknown invisible world of microscopic living beings, was a minor civic official. Leibnitz, one of the originators of the infinitesimal calculus, was a diplomat and courtier.

Priests and pharmacists, physicians and merchants were the contributors to scientific knowledge. Even the professors whose names stand out among the founders of science cannot be fully called professionals. They earned their living by teaching the known facts of their field and only very gradually did people expect new developments from them. When they explored novel aspects of nature, it was in the private capacity of searchers for secret beauties and truths, not as paid employees.

All this changed in the 19th century. Germany came into the fore with her unheard-of pace of progress in nearly all fields of scientific inquiry. The reason for this acceleration in the attainment of knowledge was obvious: science became organized, cooperative, and supported in a hitherto unknown way by the state which controlled the universities. A professor was expected not to be satisfied with handing on static knowledge; he had the dual duties of teacher and dynamic investigator. Likewise, his assistants' tasks included the accumulation of new scientific facts, and each student was there not to receive instruction only, but to repay it with original contributions.

The number of persons active in the execution of scientific tasks had increased immensely over that in earlier centuries. Where formerly a few Royal Societies and Academies had assembled friends with adventurous inclinations in the realm of thought, there originated then hundreds of societies of naturalists, physicists, chemists, physiologists, with super associations for the "Advancement of Science" to unify the various groups of investigators separated into their specialized organizations. Where a few *Proceedings* and *Transactions* had been sufficient to store the harvest of scientific labor, now untold *Zeitschriften, Journals,* and *Archives* for a host of disciplines seemed hardly able to provide space for the outpourings from the laboratories.

From Germany this development spread to wherever modern methods of research were followed. Still, some countries, notably England, preserved more of the original attitude than others. Joule, the physicist, was a brewer, and Charles Darwin a well-to-do owner of a country estate from which he gained his income. In our own time it may be difficult to match the illustrious examples just given, though a series of important English free lance investigators could be named. England, too, had to follow the large scale, cooperative trend, but the amateur tradition still appears strong in guiding even her professionals. It need not concern us here that the independence of the nonprofessional scientist in England had been causally connected with the specific social and economic stratification of that country. In America the organization of science has reached its climax with a National Research Council, with hundreds of universities and colleges which foster research, great endowed institutes for pure and applied science, foundations, and nearly 30,000 investigators listed in *American Men of Science* (which in spite of its title designs to include American Women of Science also).

Science has become a profession. To be a scientist still can carry with it all the inner rewards which a deep, detached human activity bears, but it also pays in hard cash, in promotion in academic rank, in prestige within one's own group, and even in the outside world. Instead of letting the investigator find supreme happiness in his journeying, we have built up a system of compensating him for reaching a goal. Memberships in select societies, presidencies and vice-presidencies, medals, prizes, and "immortalities" of five or more years' duration, acknowledged by small or large groups of colleagues, attempt to lure the wanderer away from a more appropriate view of his task.

## III

The deflection of the scientist from his original path is particularly easy when the

products of his work lead to practical results. It is significant in this respect that some fields of science have been able to retain more of their primal status than others, and with everyone's full approval. Whose heart does not beat faster when he hears of the astronomer's search? Who doubts the value of the archeologist's labors? Astronomy and archeology, together with some other branches of endeavor, escaped most of the conflict between their intrinsic and applied values. Nobody expects the efforts of their devotees to lead to new cures for frailties of the body or to the discovery of still more servants of man. We cannot "sell" these disciplines for their pragmatic worth—and we discover that we need not do so Understanding for their functions exists and support is offered without demand for a quantitative balance sheet of money received and products delivered.

It is different in those fields where hopes for practical achievements are obvious. Rightly we direct specific efforts to such goals and rightly do we expect every opportunity to be grasped which may offer help and relief in our daily lives. Even when we contemplatively follow our paths and without thought of final application, we know that such application might, nay, will be forthcoming some day. But also, how convenient do we find it, when we doubt ourselves or are afraid of standing up for our cause, to recall that "fool-experiments" so often turned out to be the beginning of most rewarding practical pursuits. Thus we betray the other motive of our labors, and are the poorer for it. Nor is this our only loss. We permit the misplaced emphasis on the practical accomplishments of some of the Natural Sciences to separate us from our comrades in spirit, the Humanities. All mankind suffers under such lack of understanding, not only the individual disciplines on both sides of the barrier. For what should these disciplines be but interrelated attributes of man and not specialties of men!

## IV

Unlike the tangible results, the ideological basis of science cannot be advertised in striking headlines; such as, "Tea acts as stimulant in the morning, as sedative at night, says scientist." Too often even scientists themselves lose sight of the purposeless aspects of their calling; particularly since they have to devote so much time to the mastering of tools that many never graduate from the state of the—however accomplished—technician to that of the scholar.

Some years ago I revisited one of the great institutions of research in this country. I was glad once again to see my colleagues in age and experience and to meet the somewhat younger members whose contributions had earned them respected names. We talked about the developments current in this center, about everybody's problems, ideas, and accomplishments. It was a group of friendly cooperators. Each shared his thoughts with the others and each quoted freely the views of the next, not forgetting to give due credit to the originator. There was no mention of one man, a somewhat older member of the laboratory, not by any means an old man, for he had not yet ended the fifth decade of his life. When we bright young men were still in grade or high school, he was already following an intricate path in science, the description of which has become one of the rare, true classics in his field. It had been the opening fanfare to a series of discoveries of lasting beauty. The name of this man inevitably would come to mind among the first when one thought of this group which his ideas had helped to found.

"How about Sedgwick?", I inquired. "Sedgwick?"—embarrassed shrugging of shoulders. Good old Sedgwick, he did not swim in the common stream. He did not participate very much in the most modern discussions. He tried to linger along the routes which the army whose advance guard he once formed had left behind. To smooth the roads, to open some pretty side views was not completely useless, my friends said, but was it not too bad to stay away from the joint, cooperative attempt to add a new mile to the highway?

The later comers had forgotten the beginnings of the highway. Dreamy followers of crooked paths had been their predecessors. Had the man, whose absence in their midst they considered with regretful condescension, remained on the highway of his period,

instead of wandering on side lanes, they would not have been able to push along their well-planned drive. However, this forgetfulness was not what saddened me, but rather that the younger group did not recognize the grandeur of the lonely beholder of hidden vistas, regardless of whether these might become the vantage points of hordes of exploiters or whether they remained obscure. My friends were not immune to the urge to wander in solitude, but they did not realize that those rarer moments of their lives embodied more of an essential feature of man's cause than the long periods of goal-hunting cooperation.

It really spoils the moral of this story, but I cannot refrain from mentioning that some of the side views, which the man whom we called Sedgwick has cut out since that episode, have led to broad bases for cohorts of followers.

## V

We are often told that the value of scientific cooperation extends beyond its immediate goal, that it is a form of altruism which by necessity paves the way for larger efforts of human collaboration. Here is a group of people who practice daily the moral teaching of mutual help. Must they not be led to adopt a general attitude of humane spirit? Alas, this is not much more than a pious hope. Do not business men join in associations in which they cooperate according to a circumscribed code—and do they not engage in violent competition among themselves in spite of it? Do not the teachings of patriotism and nationalism imply a worthy cooperation within large groups of individuals and do they not too often at the same time set rigid limits to brotherly love and even incite to hatred toward those outside one's own nation?

Nowhere could the supposed effect of scientific cooperation be better tested than in international scientific congresses. Here often fifty or more different nations, of different cultural background, of different skin color, and with most diverse political problems and goals peacefully sent delegates to one common meeting-ground to discuss scientific matters, to live together, to join in common receptions, dinner-parties, and excursions. Never did the welcoming speakers forget to tell such a gathering that it represents a hopeful sign, a new link in the bond that will bring all the peoples together in civilized cooperation. But watch the individual delegates! Observe the fight to have this or that tongue admitted as an official language of the congress. Follow the struggle as to which country will carry away the prestige—not the honor—of being the seat of the next international meeting. Many of the scientists seem to regard the congress as an arena in which to exhibit the virtues of their nation, a battlefield on which to guard their people jealously against any attacks from the enemies. Yes, one could tell true stories where the housing of some delegates on the fourteenth instead of the fifteenth floor of the dormitory—or was it the reverse? —had been turned into a "diplomatic" affair!

However, this is indeed not a complete picture. There were sincere sentiments present among the participants of such cooperative meetings so that general human understanding and mutual help in *all* civilized endeavors were sought. Bonds between nations became visible and artificial barriers disappeared. The contrast between national jealousies and honest joining of hands is not to be wondered at. Science as a technique, as a profession out for results—why should it foster wider human ideals? It is a closed system in which purposes, if fulfilled, constitute its own limits. On the contrary, science as an expression of a deep general human trait, as the detached attitude of the enchanted searcher and spectator transcends itself in wanting all truly human qualities expressed without external restraint. The comradeship of the great has always disregarded artificial boundaries of space and even those of time.

It is perhaps not without significance that English scholars have been among those who showed the clearest realization of the wider aspects of the supranationalism of science. The attitude of the amateur, the lover of his labors, is, as we saw, still widely spread in England. Continental scientists as a group are much more professionalized and, besides, they have been taught to think in separate compartments: collaboration in obtaining re-

sults—and use of the collaborative product for mutual destruction. In America, as in England, scientists are freer from prejudices than elsewhere. However, it may be wondered what strain the American attitude could bear since this freedom is based less often on the deep recognition of the cultural motive of scientific search than on a fortunate lack of narrow nationalism.

## VI

The line of separation between amateur and professional, between scholar and technician, between the wanderer and the goal-hunter, does not separate individual from individual. It passes through most of us who are engaged in the pursuit of science. The student who devotes himself with the greatest abandon to the human value of his interests finds it hard to attain freedom from personal vanity and professional pride, while even the most mechanized worker cannot help feeling some of the joys of independence.

This essay does not attempt to preach a *l'art pour l'art* attitude, a hopeless undertaking—even if it were desirable—in this time when the heralds of the social significance of science fill the air with their pronouncements. But we need a wider and deeper realization of the value of science as an expression of a detached essence of human existence. Even scientists often answer the question of why they devote themselves to their work by replying that they do so because it is fun! It is important, however, to understand that the pleasure which the investigator derives from his work contains an element of a nature different from that inherent in an hour of ephemeral play. The "fun" of the investigator transcends the individual and attains its social justification as an attribute of humanity.

As important as the planning and the cooperative effort of scientific undertakings is, it follows from these considerations that society should not subsidize and organize science only for its results pure or applied. It should foster science in the same spirit in which it erects museums, churches, and "useless" monuments, in which it delegates painters and sculptors to adorn public buildings with murals and statues, in which it engages gardeners to plant flowers and beautiful trees within dusty cities, and, yes, in the spirit in which it feeds and houses the swans which draw their quiet circles on our lakes and ponds. We should learn again that, although it is not true that the journey is all and the destination nothing, the journey is worth much. "A stroller can make no detours," said Schopenhauer. We should encourage anew the roaming after knowledge for the sake of the joyful adventure. In our permanent task to give meaning to our lives it will help us at least as much to meet the lone wanderer of science as the successful member or even captain of the conquering team. The joy of the journey is never-ending, that of reaching a goal always passing.

# THOMAS PAINE: SCIENTIST-RELIGIONIST

By Ralph C Roper

When the great German-English astronomer, Sir William Herschel, first opened his inquiring eyes on the immense starry heavens (1738), Thomas Paine had already been creeping about, intent on more mundane explorations He was nine months Herschel's elder. The paths of these newcomers were destined to cross frequently, although I find no evidence that either was aware of the other.

At the age of nineteen, Herschel, with nothing more than a French crownpiece in his pocket, reached London from Hanover. Paine, who had been born in Thetford, had gone to London, where he was eking out less than a fair living. Herschel was a musician; Paine, a staymaker—of ship stays. Later, when the one was conducting concerts, the other was teaching school, and occasionally preaching on the side, as a Methodist

Both Herschel and Paine became amateur astronomers by studying the same book, Ferguson's *Astronomy*, and by listening to the same scientific and philosophical lectures at the Royal Society. To Sir Joseph Banks, president of the Society, both men submitted reports of their scientific discoveries: Herschel's, dealing with the stars of the Milky Way; and Paine's, showing the use of the arch in the construction of iron bridges. When Herschel was at Sunderland in 1761, dining "at Mr. Walker's," he was at the very same place where Paine's iron bridge—the first iron bridge traveled by commerce—was built over the River Wear, by the Messrs. Walker Foundry.

At about the same time that Herschel received a medal from the Royal Society, in recognition of his brilliant achievements in the field of astronomy, Paine was in Paris receiving the plaudits of the King and Queen of France, who, according to the French historian, Lamartine, "loaded Paine with favors." He had gone there with Colonel Laurens to secure aid for Washington's army. Incidentally, it took sixteen ox-teams to haul from Boston to Washington's headquarters the 2,500,000 livres of silver and a convoy ship of clothing and military stores, given by France to the colonies. The victory at Yorktown soon followed.

Herschel was given the honorary degree of LL.D. by Oxford University at about the same time that the University of Pennsylvania celebrated the 4th of July by granting to Paine the degree of M A.

In 1786, Herschel was elected a member of the American Philosophical Society at Philadelphia, of which Paine had been a member for a number of years. He had prepared the preamble to the act incorporating the Society, February 14, 1780, and was Clerk of the Pennsylvania Assembly at the time the act was adopted.

And so ran, in part, the lives of these two "inspired amateurs" of astronomy who came to similar conclusions as to the immensity of the heavens

The scientific activities of Paine cannot be considered separately from his religious opinions. He always approached the study of science from the viewpoint of religion, and the study of religion from the viewpoint of science. To him, the study of science was the study of God. One cannot rightly understand the scientific and religious views of Paine, nor of Franklin, Jefferson, and other Deists of their time, whether in America, France, or England, unless one realizes that they were essentially nature worshippers—God worshippers through nature. Paine built all his political, religious, and scientific principles upon the laws of nature—the laws of God. Whether occupied in the formation of a democratic constitution, or the founding of a church, or the construction of a bridge, he invariably turned to the laws and principles established by "The Great Mechanic of the Universe," "The God of Order and Harmony."

With the intrepid Thetford staymaker, all science was divine science, since God was "the Creator of Science" and all of its principles. The triangle, gravitation, and the planetary motions were all the creations of the "Almighty Power," "The Creator of the

Universe," "The Original Teacher," and "The First Philosopher."

Our first secretary of foreign affairs and his successor of one hundred and thirty-six years later, William J. Bryan, agreed upon one point, however much they disagreed upon others: that our schools and colleges tend to produce atheists. The Great Commoner, in one of his lectures, charged that the colleges were developing infidelity and atheism. "Why should the children be taught," queried Bryan, "that it is more important to know the age of the rocks than to trust in the 'Rock of Ages'? Why should the emphasis be placed on the distance between the stars than upon Him who binds 'the sweet influence of Pleiades,' 'looses the bands of Orion,' and 'guides Arcturas with His suns'?"

Rising, as it were, from the grave, and speaking again his own words, Paine could have joined the great orator in common protest against the teachers of science: "What has man to do with the Pleiades, with Orion?" asked Paine, picking up almost the very words of Bryan. And then he answered his own question: "The Almighty Lecturer, by displaying the principles of science in the structure of the universe, has invited man to study and to imitation. It is as if He had said to this globe we call ours, 'I have made an earth for man to dwell upon, and I have rendered the starry heavens visible, to teach him science and the arts. He can now provide for his own comfort, AND LEARN FROM MY MUNIFICENCE TO ALL, TO BE KIND TO ONE ANOTHER'."

Continuing in his reasoning, Paine declared that "it has been the error of the schools to teach astronomy and all other sciences and subjects of natural philosophy" as accomplishments of man; whereas, he insisted, these subjects should be taught religiously, "with reference to the *Being* who is the author of them; for all the principles of science are of divine origin. Man cannot make, invent, or contrive principles; he can only discover them, and he ought to look through the discovery to the Author."

To teach science as an accomplishment of scientists (Paine was living in an age far different from ours) is to "generate in the pupils a species of atheism. Instead of looking through the works of creation to the Creator himself, they stop short and employ the knowledge they acquire to ascribe everything they behold to innate properties of matter, and jump over all the rest by saying that matter is eternal."

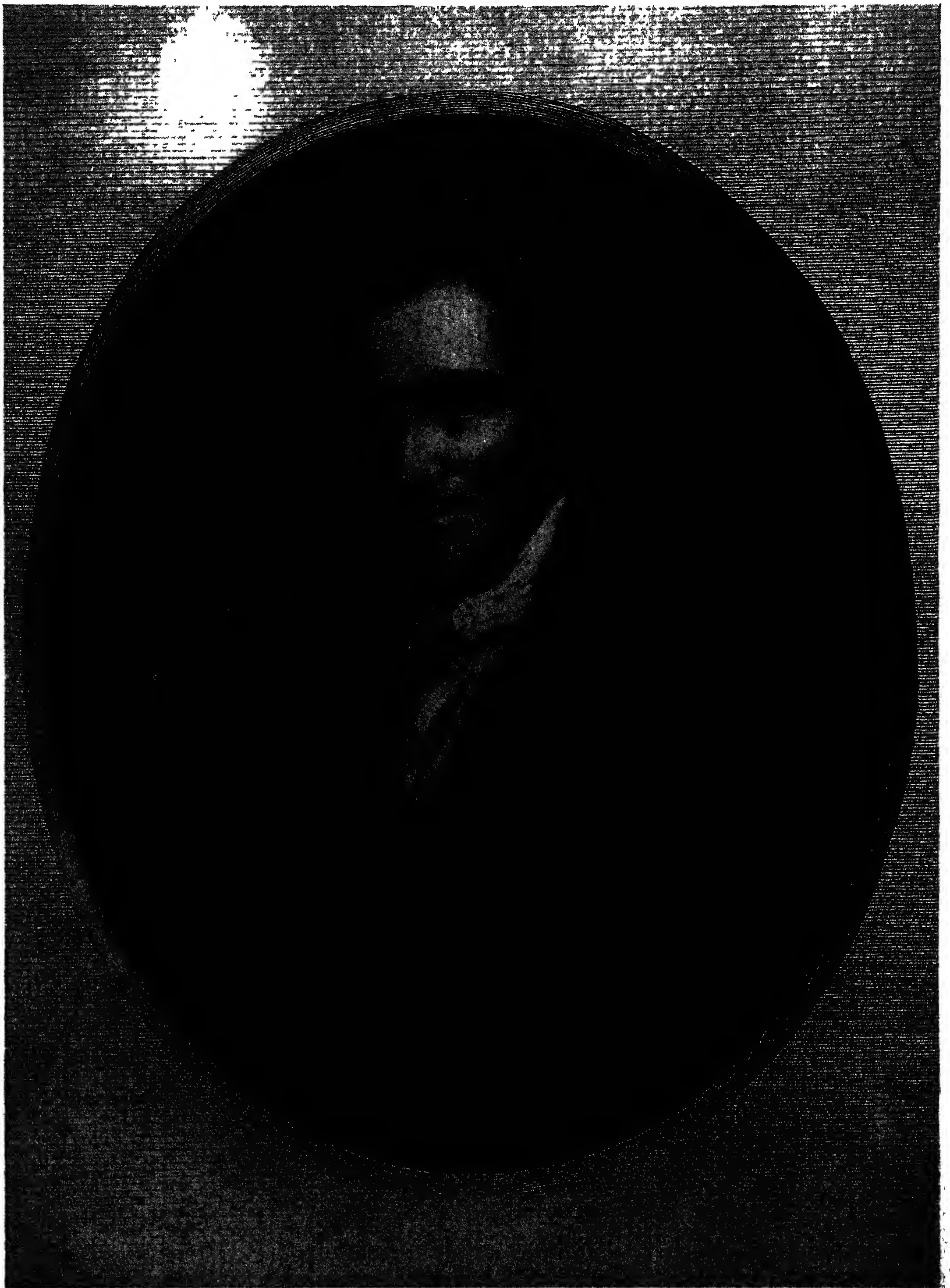
Secular schools were not alone to blame. Religious instruction, Paine insisted, had also gone wrong. Just as science should be taught religiously, so religion should be taught scientifically.

According to Paine's views, religion should not be taught solely from "opinions in written or printed books," but "in the works of the books of creation." The study of religion "in the books of opinions has often produced fanaticism, rancor, and cruelty of temper; and from hence have proceeded the numerous persecutions, the fanatical quarrels, the religious burnings and massacres, that have desolated Europe." Whereas, the teaching of religion "in the works of the Creation produces a direct contrary effect. The mind becomes at once enlightened and serene, a copy of the scene it beholds: information and adoration go hand in hand; and all the social faculties become enlarged."

And so, this preacher of science and apostle of "the religion of humanity"—a phrase which he himself coined—believed that every clergyman should be a philosopher, and every church a school of science.

"The Bible of Creation is inexhaustible in texts. Every part of science, whether connected with the geometry of the universe, with the systems of animal and vegetable life, or with the properties of inanimate matter, is a text as well for devotion as for philosophy—for gratitude as for human improvement. It will perhaps be said, that if such a revolution in the system of religion takes place, every preacher ought to be a philosopher. *Most certainly;* and every house of devotion a school of science."

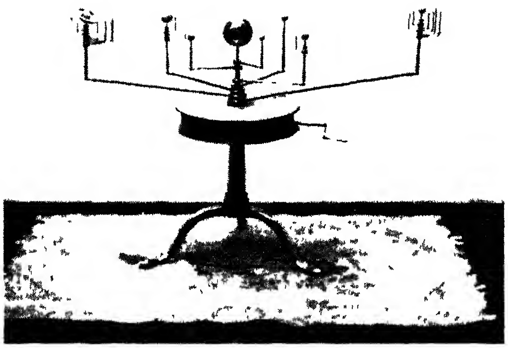
Under such a plan, they could render religion "the most delightful and entertaining of all studies," wherein "scientific instruction" could be given freely "to those who could not otherwise obtain it." "The mechanic of every profession will there be taught the mathematical principles necessary to render him proficient in his art; the cultivator will there see developed the principles



*Courtesy of Philip B. Wallace*

THOMAS PAINE, 1737–1809

ENGRAVED AFTER A PORTRAIT PAINTED IN 1792 BY HIS FRIEND, GEORGE ROMNEY, RENOWNED ENGLISH ARTIST.



*Courtesy of Francis P Witmer*
PLANETARIUM WITH SUN
ONE OF THREE MECHANICAL SET-UPS OF AN ORRERY MADE IN 1791 BY MESSRS. W & S. JONES OF LONDON.

of vegetation; while, at the same time, they will be led to see the hand of God in all things.''

Is the day approaching when such teachings will be recognized as indispensable to the larger spiritual and material abundance, when God and men may join forces to make a better world in which God and men may live more happily together?

But what about God's revelation to man?

But some, perhaps, will say: Are we to have no Word of God—no revelation? I answer, Yes; there is a Word of God; there is a revelation.

THE WORD OF GOD IS THE CREATION WE BEHOLD, and it is *this word*, which no human invention can counterfeit, that God speaketh universally to men.

It is only in this Creation that all our ideas and conceptions of a Word of God can unite. The Creation speaks a universal language independently of human speech or human language, multipled and various as they be. It is an ever-existing original, which every man can read. It cannot be forged; it cannot be counterfeited; it cannot be lost; it cannot be altered; it cannot be suppressed. It does not depend upon the will of man whether it shall be published or not; it publishes itself from one end of the earth to the other. It preaches to all nations and to all worlds; and this Word of God reveals to mankind all that is necessary for man to know of God.

Do we want to know His power? We see it in the immensity of the Creation. Do we want to contemplate His wisdom? We see it in the unchangeable order by which the incomprehensible whole is governed. Do we want to contemplate His munificence? We see it in the abundance with which He fills the earth. Do we want to contemplate His mercy? We see it in His not withholding that abundance even from the unthankful. In fine, do we want to know what God is? Search not the book called the Scripture, which any man might make, but the Scripture called the Creation.

Twenty-one years before Herschel wrote his final conclusions (1818) on the *Nebulae*, ''Island Universes,'' ''Nebular System,'' ''Planetary Clouds,'' ''1500 universes,'' and ''how the heavens move,'' Thomas Paine had discussed in *The Age of Reason* essentially the same subjects. The first part of this book was mainly a treatise on astronomy.

Astronomer Paine enjoyed nothing more than to study the plurality of worlds, systems, and universes of worlds, in the infinitude of space; in which our little earth ''is suspended, like a bubble or balloon in the air,'' like ''the smallest grain of sand is to the size of the world,'' or ''the finest particle of dew to the whole ocean.'' And so on and on he penetrated into space, trying to find the end, ''till the fatigued imagination returns and says, *There is no end.*''

Wrote Herschel in 1817: ''Our sun, with all the stars we can see with the eye, are deeply immersed in the Milky Way, and form a component part of it.''

Wrote Paine in 1797: The sun and its system of planets, ''immense as it is, is only one system of worlds. Beyond this, at a vast distance into space, far beyond all power of calculation, are the stars called fixed stars. They are called fixed because they have no revolutionary motion, as the six worlds or planets have that I have been describing. Those fixed stars continue always the same distance from each other, and always in the same place, as the sun does in the center of our system.''

Then, here again Paine anticipated Herschel: ''The probability, therefore, is that each of those fixed stars is also a sun, round which another system of worlds, or planets, though too remote for us to discover, performs its revolutions, as our system of worlds does around our sun.'' Paine theorized that these worlds, like our own, are populated with human beings, or beings of some kind. His reasoning was not based alone on his peering into the infinity of spaces. He looked about him and saw the earth and the waters and the air filled with life, from the largest animals to those ''totally invisible without the assistance of a microscope. Every tree,

every plant, every leaf serves not only as a habitation but as a world to some numerous race, till animal existence becomes so exceedingly refined that the effluvia of a blade of grass would be food for thousands."

And then Paine queries: Since no part of the earth is unoccupied by life, "why is it to be supposed that the immensity of space is a naked void, lying in eternal waste? There is room for millions of worlds as large or larger than ours, and each of them millions of miles apart from each other."

Discussing further his theory of the plurality of worlds:

> But it is not to us, the inhabitants of this globe, only, that the benefits arising from a plurality of worlds are limited. The inhabitants of each of the worlds of which our system is composed enjoy the same opportunities of knowledge as we do. They behold the revolutionary motions of the earth, as we behold theirs. All the planets revolve in sight of each other, and, therefore, the same universal school of science presents itself to all. Neither does the knowledge stop here. The system of worlds next to us exhibits, in its revolutions, the same principles and school of science to the inhabitants of their system as our system does to us, and in like manner throughout the immensity of space.
>
> Our ideas not only of the Almightiness of the Creator, but of His wisdom and beneficence, become large in proportion as we contemplate the extent and the structure of the universe. The solitary idea of a solitary world rolling or at rest in the immense ocean of space gives place to the cheerful idea of a society of worlds so happily contrived as to administer, even by their motion, instruction to man. We see our earth filled with abundance, but we forget to consider how much of that abundance is owing to the scientific knowledge the vast machinery of the universe has unfolded.

And then, in his characteristic way, which made for him many and bitter enemies among the orthodox theologians of his day, Paine criticised what he believed to be the exclusiveness of the Christian faith:

> But, in the midst of these reflections, what are we to think of the Christian system of faith that forms itself upon the idea of one world only, and that of no greater extent, as is before shown, than twenty-five thousand miles? An extent of which a man walking at the rate of three miles an hour, for twelve hours in a day, could he keep on in a circular direction, would walk entirely around in less than two years. Alas! What is this to the mighty ocean of space, and the almighty power of the Creator?
>
> From whence, then, could arise the solitary and strange conceit that the Almighty, who had millions of worlds equally dependent on His protection, should quit the care of all the rest, and come to die in our world, because, they say, one man and one woman had eaten an apple?
>
> Could a man be placed in a position, and endowed with the power of vision, to behold at one view, and to contemplate deliberately, the structure of the universe; to mark the movements of the several planets, the cause of their varying appearances, the unerring order in which they revolve, even to the remotest comet; their connection and dependance on each other, and to know the system of laws established by the Creator, that governs and regulates the whole, he would then conceive, far beyond what any church theology can teach him, the power, the wisdom, the vastness, the magnificence of the Creator; he would then see, that all the knowledge man has of science, and that all the mechanical arts by which he renders his situation comfortable here, are derived from that source; his mind, exalted by the scene, and convinced by the fact, would increase in gratitude as it increased in knowledge; his religion and his worship would become united with his improvement as a man; any employment he followed, that had any connection with the principles of creation, as everything of agriculture, of science and of the mechanical arts have, would teach him more of God, and of the gratitude he owes to Him, than any theological Christian sermon he now hears.

*Courtesy of The University of Pennsylvania*

MOON SECTIONS OF RITTENHOUSE ORRERY

Had Thomas Paine never "purchased a pair of globes," or used a telescope, he might never have incurred the enmity of the fundamentalists of his day, and might have been listed among the world's sainted men.

It is exceedingly difficult in this day to comprehend how it could have been possible, even in his day, that his belief in the plurality of worlds could have been a major contributing cause of his downfall in popularity. As the inspirer of the English romantic poets and recognized leader of the 18th century revolutionary movement, perhaps no man had a greater following in England, France, and America than Paine. Yet, the publication of *The Age of Reason* (1794–95) was disastrous to his reputation. Announcement of his belief in a plurality of worlds and in the Bible of Creation brought upon him a plurality of attackers. Even as late as 1817, eight years after Paine's death, the battle was still raging.

Among the many who arose to attack his religious and scientific theories, was the Rev. Thomas Chalmers, D.D. If there are other worlds, said he, "how can we reconcile the fact with the silence of the Scriptures?" "What about revelation?" Quoting from "Mr. Andrew Fuller, in answer to Paine," Chalmers continued: "If our world be only a small province, so to speak, of God's vast empire, there is reason to hope that it is the only part of it where sin entered, except among the fallen angels; and that the endless myriads of intelligent beings in other worlds are all the hearty friends of virtue, of order, and of God." In which case, Mr. Fuller concluded, there would have been no need for the Creator to send his Son to the other worlds, as He had found it necessary to do as to the earth.

Defending the inerrancy of the science of the Bible's story of creation, and other stories, Dr. Chalmers in his answer to Paine declared: "Thus the Bible is made to speak all opinions, whether philosophical or religious. Philosophy must submit to the authority of divine revelation; until the mind is willing to make this book the standard of truth, and the foundation of knowledge, it will find no rest amidst the wanderings of the imagination, the ebullitions of vanity, and the fluctuations of sentiment."

It was a sad day for Paine to look back to —the day when he became a "master of the globes and of the orrery." How his expert operation of a miniature planetarium could have thus brought upon him an everlasting curse, is as interesting as it is incomprehensible in our time.

The Hayden Planetarium in New York City and similar places in other cities are visited by millions of people, without the least thought that they might thereby be guilty of heresy. They see the possibility of a plurality of worlds exhibited before their very eyes. There is the orrery that wrecked Paine's fame! Yet, orthodox and liberal, Catholic, Jew, and Protestant, members of all faiths and of none, flock to see the orrery in its demonstrations of our planetary system, and come away rejoicing at the marvelous scientific and spiritual lessons they have received. Each and all go away blessed and confirmed in their own religious convictions.

In order to understand the connection of the orrery in Paine's life, and the possible cause for the curse it brought upon him, let him tell his own story: "After I had made myself master of the globes and of the orrery, and conceived an idea of the infinity of space, and the eternal divisibility of matter, and had obtained at least a general knowledge of what is called natural philosophy, I began to compare, or, as I have before said, to confront the eternal evidence these things afford with the Christian system of faith."

And so, more than a century and a half ago, astronomer Paine was busy with his little planetarium, reaching the conclusion that "THE HAND THAT MADE US IS DIVINE."

In describing the orrery, Paine added this interesting footnote: "As this book may fall into the hands of persons who do not know what an orrery is, it is for their information I add this note, as the name gives no idea of the uses of the thing. The orrery has its name from the person who invented it. It is a machinery of clockwork, representing the universe in miniature, and in which the revolution of the earth round itself and round the sun, the revolution of the moon round the earth, the revolution of the planets round the sun, their relative distances from each other and their different magnitudes, are represented as they really exist in what we call the heavens."

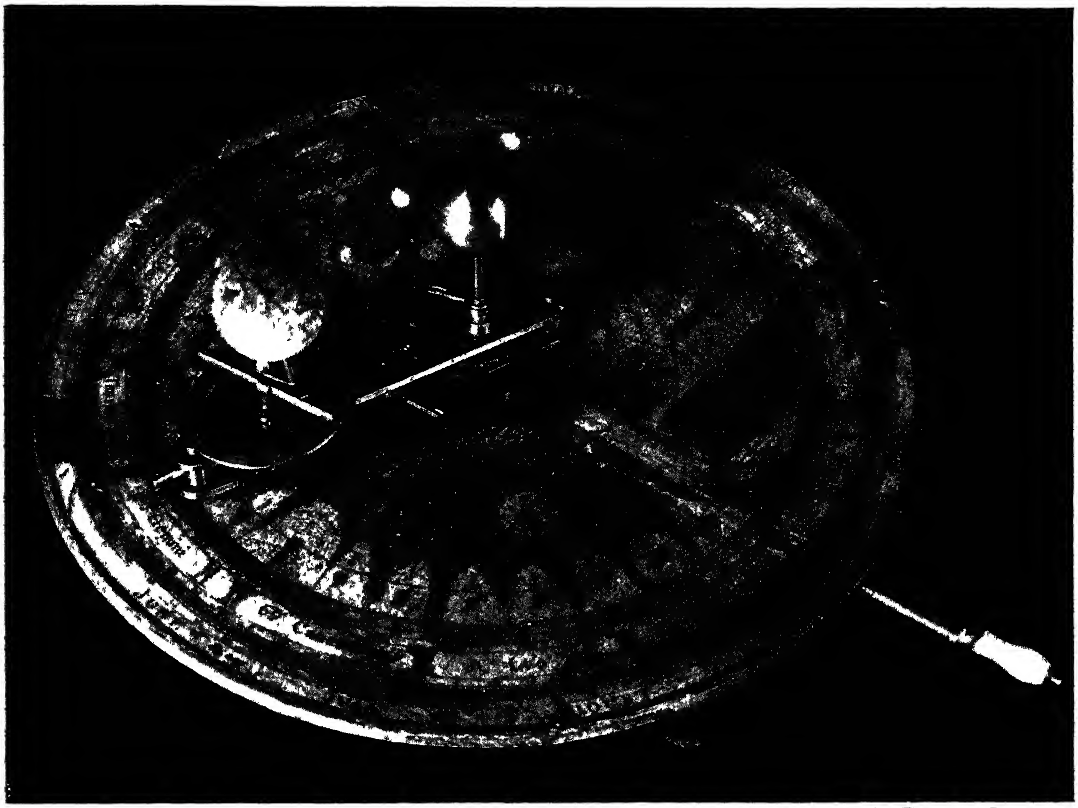
Why did Paine's belief in the plurality of worlds and in the Bible of Creation destroy his popularity? His contemporary, William Pitt, gave the answer when he said

that science and philosophy are all right, but they must be discussed among scientists and philosophers only. The masses must have none of them. That was the prevailing opinion of the time. Theology was not yet freed from the traditional chains that bound it to dogma and bigotry. The earth and its people played the most important part, indeed, the exclusive part, in the economy of the universe. That the Creator might possibly be equally interested in other worlds and other peoples seemed to be a body blow to Christianity itself. Paine wrote *The Age of Reason* for the masses to read, and they read it. That was his unpardonable sin.

But Paine did not write for the multitude alone. The intellectuals of his time also read the book, some with avidity to satisfy their craving for freedom of thought and expression in religion, and others to prepare themselves to launch bitter attacks and to heap vituperation upon Paine and his book.

In the United States, Paine's *Age of Reason* and his theories of the universe stirred up a veritable hornet's nest among the clergy and the colleges. "The effect of *The Age of Reason* on the community," declares Woodbridge Riley in his *American Thought*, "may be easily imagined. The clergy attacked it, the colleges criticized it, but the populace read it." The book spread like wild fire, especially throughout the West and the South. I recall that in the pioneer days in the West, debating clubs and cracker barrel forums discussed the many theological issues that the book raised. Lincoln read it and wrote a similar book on the Bible. Fortunately for him and the country, his friend Hall threw the manuscript into the stove. Paine's book was published; Lincoln's was not. Publicity has much to do with men's reputations.

Paine's most prolific and distinguished opponent in the United States was President



*Courtesy of The Franklin Institute*

SMALL HAND-DRIVEN ORRERY

MADE IN 1795 BY MESSRS. W. & S. JONES OF LONDON. ONCE OWNED BY J. B. PRIESTLEY, FRIEND OF PAINE.

Timothy Dwight of Yale University. As the leader of the opposition, he did much to make Paine the recognized leader of the Deistic movement that swept the country. At Harvard University, the situation became complicated: students neglected their studies to read Paine's book! And why not? Had not the president of Harvard requested Paine to write a poem on *The Invention of Letters,* and had it not been delivered in Cambridge on the day of the annual commencement, July 15th, 1795? Down at Princeton University, "*The Age of Reason* was opposed by the philosophy of common sense," declares Riley.

The Deistic movement waned and finally disappeared. An important outgrowth was the New England Transcendentalism. "It denied the need of miracle, revelation, dependence on an outward standard of faith; it affirmed the need of intuition, mystic ecstacy, inward dependence upon an immanent life. As the philosopher of Concord exclaimed: 'Here is now a perfect religion, which can be set in an intelligible and convincing manner before all men by their reason'."

Paine not only dabbled in the physical sciences, but also in the metaphysical. The spiritual side of science was more attractive to him. Much as Emerson was a mystic, so was Paine, and both got their greatest inspiration from the teachings of the Orient.

Paine and Emerson both stressed the creative power of THOUGHT. To which Paine added MOTION. Thought and Motion—these were the creative forces of both God and man. Paine characterized God as "Universal Mind," the "First Cause"—the Mind that had spoken the Word and thereby had called forth the universe, and had sustained it by motion This was Paine's theory of creation—quite in line with the Genesis story.

In thus advancing the theory of the control of mind over matter, that mind preceded matter, Paine seems to have anticipated some present-day scientists, including Sir James Jeans, Sir Arthur Stanley Eddington, Professor Robert A. Millikan, and others, who seem to believe (quoting the words of Jeans) that "science almost approaches unanimity" in its claim that "the stream of knowledge is headed toward non-mechanical reality"; that the universe now begins to look more like "a great thought than like a machine"; and that scientists now suspect that mind should be hailed as "the creator and governor of the realm of matter."

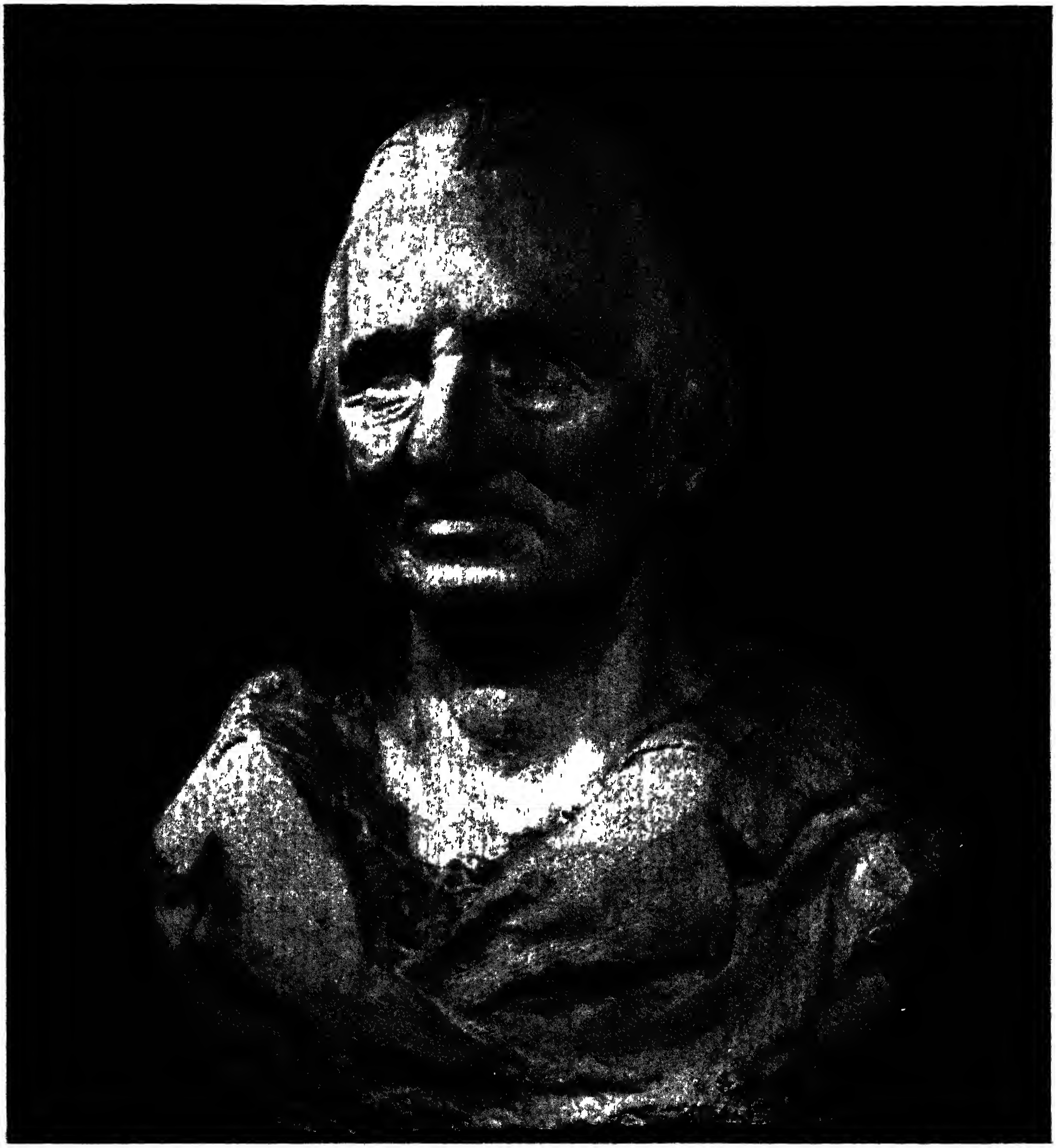
That Paine delved into the realm of metaphysics, and discussed, in his characteristic way, the creative powers of thought and motion, are matters which have not heretofore been pointed out, I believe, in any biographical or periodical writings on Paine. Let us, then, take a look at Paine, the metaphysician.

Paine delighted to speculate in theories of thought creations, thought vibrations, the power of motion, and how we get our thoughts, as he did to experiment in concrete forms of government or in the motive power of steam and gunpowder.

First of all: how do thoughts get about? Paraphrasing Paine's words: Thoughts get about, man knows not how, and once released, they cannot be recalled They wind their progress from nation to nation, and conquer by a silent operation. Man finds himself changed, he scarcely perceives how. Thoughts are more powerful than armies. "An army of principles will penetrate where an army of soldiers cannot go; it will succeed where diplomatic management would fail; it is neither the Rhine, the Channel, nor the Ocean that can arrest its progress; it will march on the horizon of the world, and it will conquer" Behold, the power of thought!

Paine conceived God as a Being of mind and will, "a Being whose power is equal to His will." His definition comprehends the power to *will* into existence that which he wished to create. The will of man, declared Paine, "is of infinite quality," the limits of which "we cannot conceive." But how "exceedingly limited is his power of acting compared with the nature of his will. If man's powers were equal to his will, he would be God," for "he would will himself eternal, and be so. He could will a creation, and could make it."

"In this progressive reasoning," continued Paine, "we see in the nature of the will of man half of that which we conceive in thinking of God; add the other half, and we have the whole idea of a Being who could make the universe, and sustain it by perpetual motion;



*Courtesy of The New-York Historical Society, New York City*

BUST OF THOMAS PAINE, BY JOHN WESLEY JARVIS

because He could create that motion." "How numerous are the degrees, and how immense is the difference of power, from a mite to a man."

"Since, then, everything we see below us shows progression of power, where is the difficulty in supposing that there is, at *the summit of all things,* a Being in whom an infinity of power unites with the infinity of the will? When this simple idea presents itself to our mind, we have an idea of a perfect Being that man calls God."

"It is comfortable to live under the belief of the existence of an infinite protecting power; and it is an addition to that comfort to know that such a belief is not a mere conceit of the imagination," but "a belief deducible by the action of reason upon the things that compose the system of the universe; a belief arising out of visible facts."

Emerson put forth the idea that thoughts are immortal once they are vibrated into the ether; that the ether is an infinite reservoir of our thoughts; that we may pick them up out of the ether if we are mentally attuned to its vibrations; and that we may think the thoughts of Plato and of the saints.

Paine divided thoughts into two kinds: "those that we produce in ourselves by reflection and the act of thinking, and those that bolt into the mind of their own accord." And then he made a statement, which, if science should ever sustain it, might account for Paine's uncanny capacity for knowledge: "I have always made it a rule to treat these voluntary visitors with civility, taking care to examine, as well as I was able, if they were worth entertaining, and it is from them that I acquired almost all the knowledge that I have."

What a challenging statement! Did Paine there disclose the secret of his extraordinary powers? Did he write and act under "inspiration"? Dr. Alexis Carrel, Nobel prize winner and Rockefeller Foundation authority, has said that "great discoveries are not the product of intelligence alone"; that "all great men are endowed with intuition," which "phenomenon in former times was called inspiration."

But motion, Paine believed, had to accompany thought to make it creative. Here was his theory: "The universe is composed of matter, and, as a system, is sustained by motion. Motion is *not a property of matter,* and without this motion the solar system could not exist." The motion that upholds the solar system "operates to *perpetual preservation,* and to prevent *any change* in the state of the system."

"When, therefore, we discover a circumstance of such immense importance that without it the universe could not exist, and for which neither matter, nor any nor all the properties can account, we are by necessity forced into the rational conformable belief in the existence of a cause superior to matter, and that cause man calls God."

And then Paine hurled his famous challenge at the atheists: "Who then breathed into the system the life of motion? What power impelled the planets to move?" "Where will infidelity, where will atheism, find cause for this astounding velocity of motion, never ceasing, never varying, and which is the preservation of the earth in its orbit?" "The atheist who affects to reason, and the fanatic who rejects reason, plunge themselves alike into inextricable difficulties."

Professor Harry Hayden Clark of the University of Wisconsin, long a student and writer on Paine's ideas and activities, suggests that he may have derived his explanation of planetary motion from Newton, who, in his letters to Bentley, "postulates a divine power as necessary to explain planetary motion." Professor Clark observes that Paine saw "in the structure of the universe," "an unerring regularity of the visible solar system," "the God of Order and Harmony," "the Supreme Architect of the Universe." Declared Paine: "This harmony in the works of God is so obvious that the farmer in the field, though he cannot calculate eclipses, is as sensible of them as the philosophical astronomer. He sees the God of Order in every part of the visible universe."

But, how did motion begin? Here was Paine's answer: The "Power that *called* us into being." To have *sounded* the *call* was enough to have started all the machinery of the universe into action!

Paine's theory that God *called* forth the universe, and *called* motion into action to sustain His creation, was more in harmony with the Genesis story of creation than his attackers realized. We are told that "the Spirit of God *moved* upon the face of the waters." Four times in the first chapter of Genesis, we find the expression: "And God *called.*" The phrase "And God *said*" appears nine times in the same chapter. It thus seems, according to the Bible, that God *spoke,* and His handiwork came forth into being.

Let us now turn to the field of applied science and invention. In this field also, Paine demonstrated considerable genius. His friend, Joel Barlow, once wrote: "Biographers of Paine should not forget his mathematical acquirements and his mechanical genius." Among his numerous inventions were a planing machine, a new crane, a smokeless candle, a wheel of concentric rim, a scheme for using gunpowder as a propel-

lent, and other items. Dr. John Wakefield Francis, who, as a young man, had known Paine, in his recollections of *Old New York,* praises Paine's "timely" article, written in 1806, entitled, "The Cause of Yellow Fever."

Paine's real contribution to the invention of the steamboat has been established. Paine, Fitch, Rumsey, and Fulton conducted their experiments independently. They were all close friends. Sir Richard Phillips, who assisted Fulton in his steamboat experiments on the Thames, gives credit to Paine in a controversy between Fitch and Rumsey, both of whom admitted Paine's priority in the application of steam to navigation. Fulton, to whom Paine gave all of his papers and experiments, received all the credit for the steamboat.

Newton saw an apple fall, and announced the law of gravitation. Paine watched a spider spin its web, and designed the first cast-iron bridge. Patent No. 1667 for his bridge was issued to Paine by "His Most Excellent Majesty King George the Third," whom Paine had characterized as the "Royal Brute" in the fight for American Independence. James Parton has reminded us that it was the principle of Paine's arch that "now sustains the marvelous railroad depots that half abolish the distinction between indoors and out." And Dr. Robert Collyer, at the opening of the Brooklyn bridge, observed that to Paine belonged the credit of the great invention, and deplored the fact that ignorance and bigotry had meanly denied it to him.

I have in my possession a picture of the cast-iron bridge built over the River Wear at Sunderland. Paine's patent was issued in 1788. I also have a letter, dated November 7th, 1936, signed by J. A. Charlton Deas, Director of the County Borough of Sunderland, Public Libraries, Museum and Art Gallery, of Sunderland, certifying as to the bridge built under Paine's patent. The writer states: "The Wearmouth Bridge Foundation Stone was laid with Masonic honours, 24th September, 1793; the bridge was opened 9th August, 1796. . . . Built of cast iron and with a span of 236 feet, it was one of the most daring structures ever built in this material" The writer further states: "In 1859 the roadway was leveled and the structure widened and strengthened by Robert Stephenson. When the bridge was demolished in 1929 (having become too narrow for modern traffic), the original cast iron ribs were found to be in perfect condition."

The famous Cathedral of Notre Dame in Paris housed, for a time, the religious services of The Society of Theophilanthropists, which was founded by Paine and five families, in 1797. The name, a combination of three Greek words, signify God, Love, and Man. Paine delivered the inauguration sermon entitled "The Existence of God." Throughout his writings, we find an intense belief in a common unity, a common brotherhood, and a common faith—faith in the ultimate freedom of all mankind. Freedom of body, freedom of mind, and freedom of soul. To these freedoms he dedicated his life. Great men and women of science, in all countries, may well consecrate their lives to the achievement of these freedoms, in the spirit of '76, as expressed by Paine in these words:

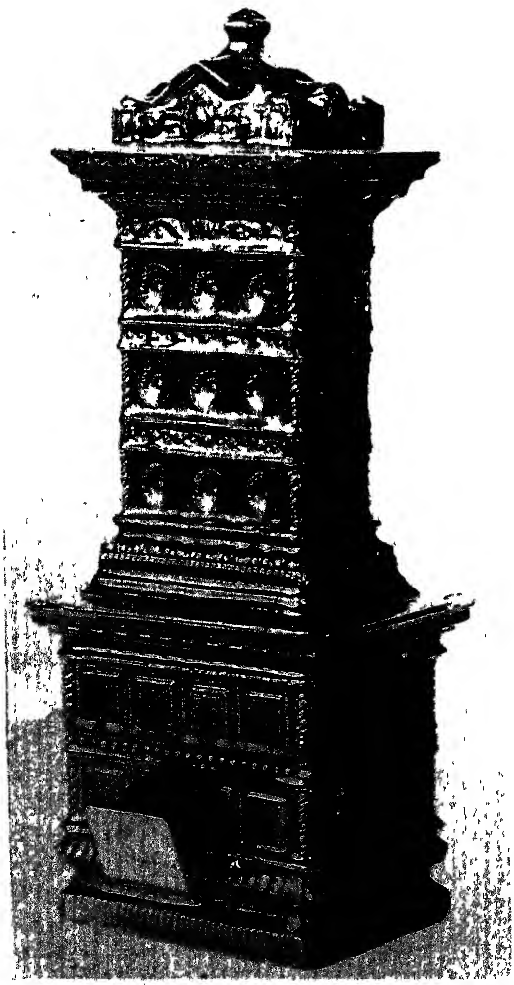
> These are the times that try men's souls. The summer soldier and the sunshine patriot will, in this crisis, shrink from the service of their country; but he that stands it *now,* deserves the love and thanks of man and woman. Tyranny, like hell, is not easily conquered; yet we have this consolation with us, that the harder the conflict, the more glorious the triumph. What we obtain too cheaply, we esteem too lightly: it is dearness only that gives everything its value. Heaven knows how to put a proper price upon its goods; and it would be strange indeed if so celestial an article as FREEDOM should not be highly rated.

Thomas Paine, Citizen of the World, well said: "The world is my country, and to do good is my religion."

# STOVES MADE OF CLAY

By MERRILL WEED

WHEREVER boys are boys, someone now and then has the idea of heating the gang headquarters with a wood fire built in a length of sewer pipe. It seems to work beautifully at first. Just when the fire is roaring its merriest one side of the "stove" may fall out and spill the hot contents onto the floor The amateur fire department must then go into action pronto. The boys learn that sewer pipe is not designed for such service.



*Courtesy of U. S. National Museum*
**MODEL OF A NORWEGIAN TILE STOVE**

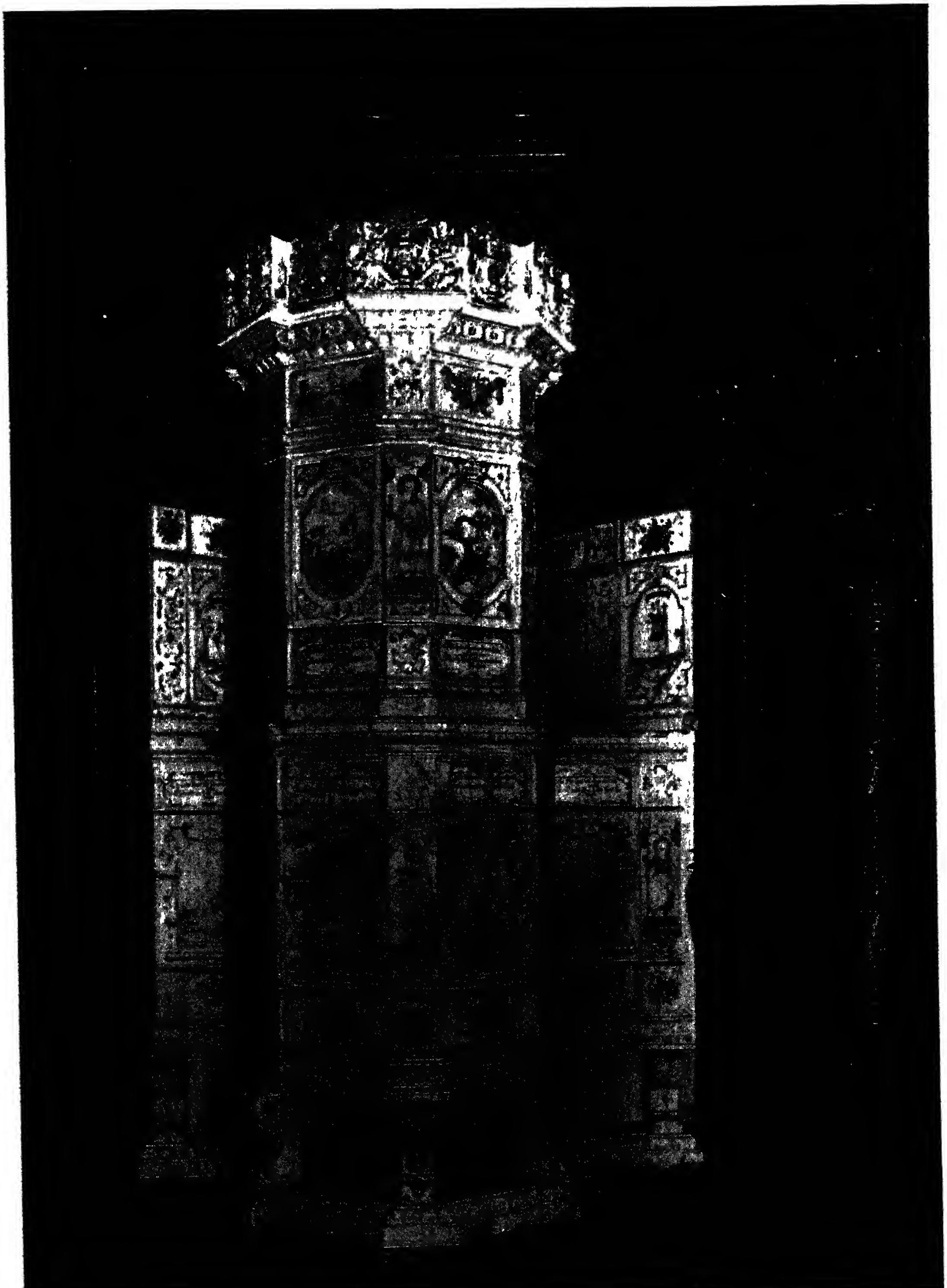
Such attempts as this are about as far as we have gone in the United States toward making stoves out of clay. To be sure, open fireplaces are built of firebrick, and many stoves and furnaces have the firebox lined with brick that will stand high temperatures. But our stoves, both heaters and cooking ranges, always have been made of metal.

In parts of the Old World the winter center of life and warmth in the house is often a large and ornate *Porzellanofen* or porcelain stove, splendid with its surface of richly colored enameled tiles. This kind of stove, also called *Kachelofen* or tile stove, got its start in Germany at a time when iron was scarce and much in demand for making armor. It came to be widely used in central Europe. Craftsmen assembled the bricks for the fire chamber and applied the ornamental pattern of tiles These stoves are heavy and expensive, definitely built into the houses they warm. They have been greatly admired by American travelers, but not many of them have been brought to the United States.

Two of the illustrations are of such European stoves; one shows a richly decorated stove in a period room at the Metropolitan Museum of Art, New York, the other is a model, in the Smithsonian Institution, of a tile stove from Norway.

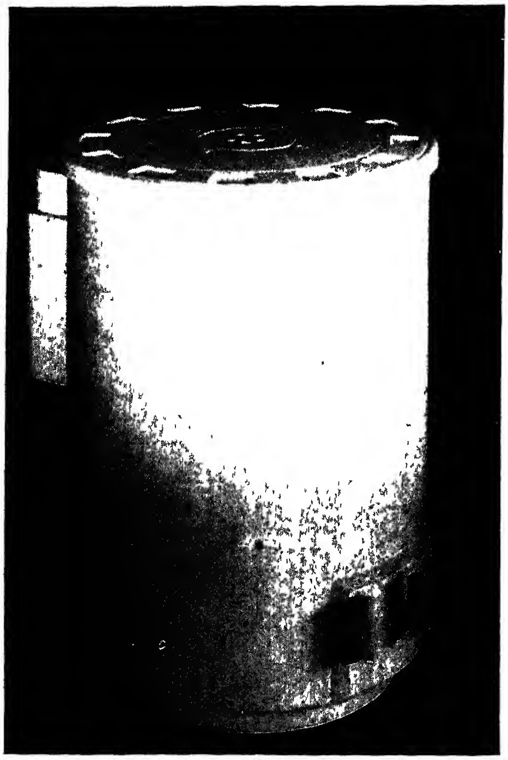
The United States, where materials have always been relatively plentiful and skilled labor is expensive, has never developed an earthenware stove industry. Now, with iron and steel made scarce by the war, experimenters are attempting to design earthenware stoves that will be scientific in operation, pleasing in appearance, and capable of being made by mass production methods

A project to develop a ceramic space heater is under way at The Ohio State University in cooperation between the Office of Production Research and Development of the War Production Board and The Ohio State University Research Foundation. Substantial progress in designing and testing



*Courtesy of The Metropolitan Museum of Art.*

FAIENCE STOVE, SWISS, 17TH CENTURY, DECORATED WITH BIBLICAL SCENES



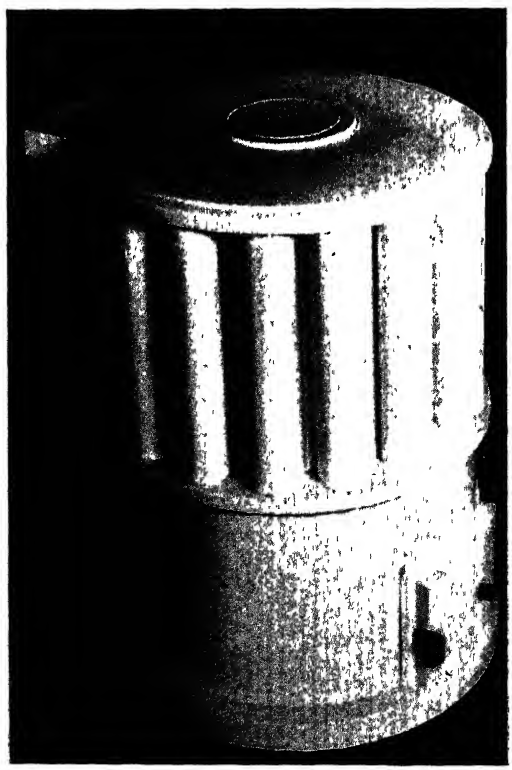
THE ROUND CERAMIC STOVE

prototype models was reported at a recent conference in Columbus that received wide interest from clay products manufacturers and makers and distributors of stoves. The requirements mentioned were good looks, as small size and as easy shipping as good engineering will permit, delivery of thirty to forty thousand B.t.u. per hour, use of no metal or of very few metal parts, and cost of from fifty to one hundred dollars.

Houses in Europe are ordinarily not kept at the cozy temperatures to which Americans are accustomed. To be successful, the final design must suit American conditions. In Europe the fuel is ordinarily wood or charcoal; stoves for use in this country need to be able to burn wood or bituminous coal and at a fast enough rate to keep a good-sized room comfortably warm.

The fact that heat transfer is slower in ceramic material than in metal makes it necessary to design the ceramic stove so the hot gases will remain longer in contact with the heating surfaces than they ordinarily do in iron stoves. Experiments have shown that a down draft for the flue gases gives too much trouble with soot. Accordingly, the stoves have been designed so the hot gases will travel upward next to the outer surface of the heater. A magazine in the top holds a twelve-hour supply of coal. The heat cokes the fresh fuel, and a down draft through the magazine brings the coal gases to the fire chamber where they are burned. Burning the gas that is given off increases the efficiency of the heater and reduces the amount of soot and smoke.

The coke from the magazine is fed automatically to the grates, which may themselves be of ceramic materials The hot flue gases then pass up through fire tubes on the outside of the heater next to the radiating surface. This arrangement makes the heat transfer remarkably complete, and the flue gases leave the stove relatively cool. As a further economy measure, a flue gas radiator to circulate the chimney gases and extract additional B.t.u. from them may be attached to the smoke pipe or to the chimney in an upstairs room. The gas leaves the radiator



THE "JEFFERSONIAN"

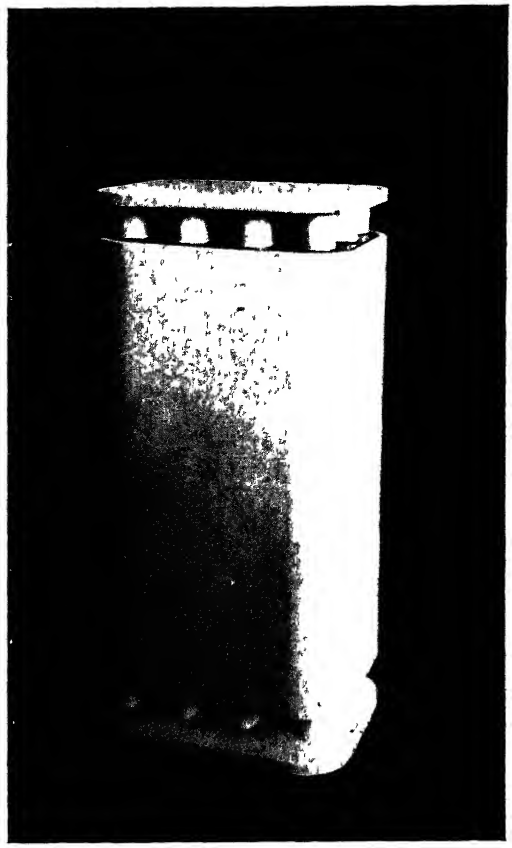
at around 300° F., about a third the temperature of flue gases from an ordinary stove.

The ability of ceramic material to retain heat should make an earthenware stove less "flashy" in operation than one of metal. It may be designed to maintain rooms at an even temperature. The effect is somewhat like that of a hot brick in keeping feet warm on a long buggy ride.

Nothing like the handwork of the *Kachelofen* is contemplated for the ceramic space heater. What is intended is that the various parts for the stove—the high-fusing materials for the fire chamber, the enameled outside surfaces, and so on—will be made in various clay products plants, with a division of the work among sewer pipe manufacturers, tile factories, and vitreous china works, and that the finished product will be assembled near the market. In that way manufacture will be decentralized and the haul to the customer shortened. Whether the stove will be shipped assembled or will be put together in the house like the European *Kachelofen* is a matter that is still under consideration. Ordinary stoves, such as mail order houses sell, reach the customers all assembled except for the legs. Shipping ceramic space heaters ready to set up may be difficult. Because of its weight and immobility, the earthenware stove is more in the class of the big base-burner than of the usual heating stove. Neither it nor the base burner could easily be set in the woodshed for the summer. As an all-year article of furniture the ceramic space heater can certainly have the advantage on looks.

As many of the parts of the ceramic stove as possible should be manufactured by extruding the clay through a die in much the same way that structural tile and sewer pipe are made. Efficient decentralized manufacture and low weight are needed to keep down the cost and the shipping charges. The minimum weight so far attained is 500 to 600 pounds, but if cellular clay and the asbestos board called "transite" can be used for some parts, the weight may be reduced.

Scientific design is only part of the development. If the ceramic stove is to stand a chance of success, it must look well. Artists have made the designs for the prototype

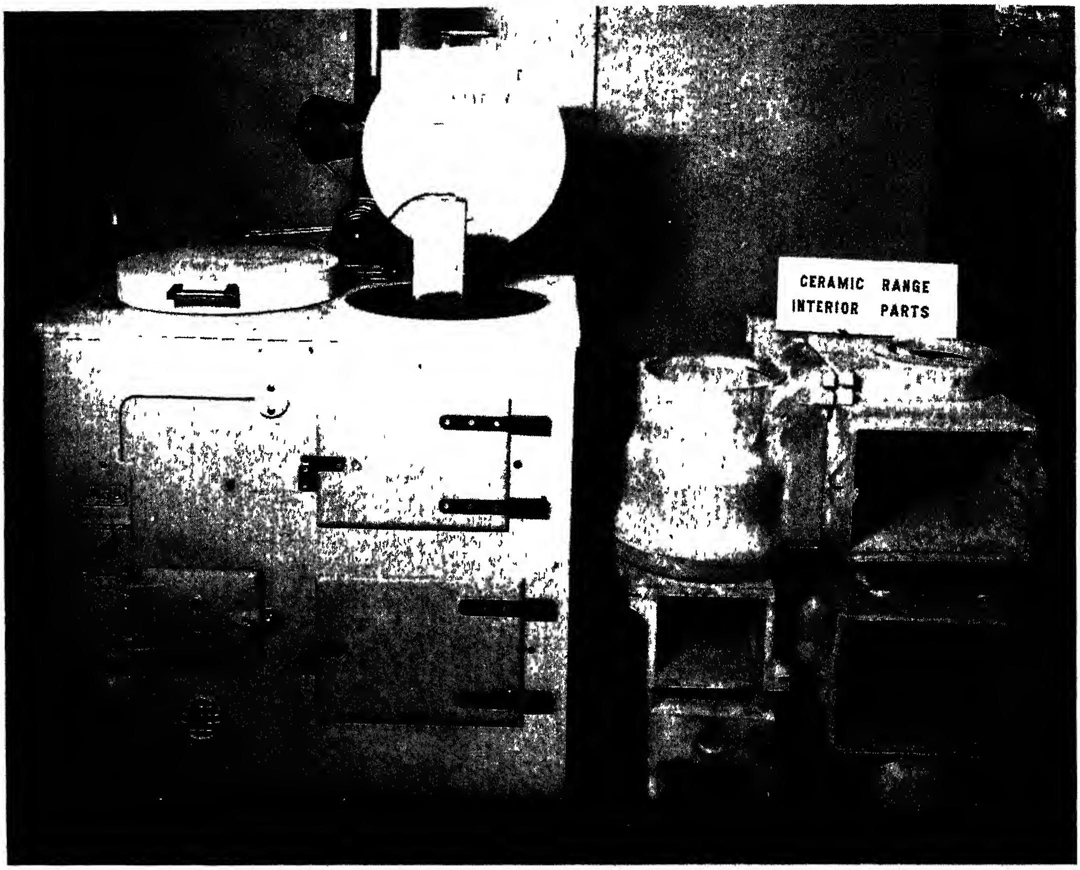


THE FLUE GAS RADIATOR

models that have been built. One is a simple round stove. The other, whose assembly of fire tubes bears some resemblance to the columns of the Jefferson Memorial in Washington, is called the Jeffersonian. If desired, the stoves may have cooking tops and ovens.

Another set of experiments in progress is pointed toward changing the Agamatic cooking range from cast iron to ceramic material. The Aga range is an expensive article designed to burn anthracite. The casting is heavy metal and the lids are about 1½ inches thick. Fuel feeds automatically from the magazine, and the stove is kept ready for use at any time. The insulation is said to be so efficient that the range is relatively economical. The pans and percolators are made to fit closely to the top, and the heat capacity of the lids is so great that the coffee percolator, for example, will begin to perk in a minute after being placed on the stove.

Preliminary tests at the National Bureau




*Courtesy of National Bureau of Standards*

THE CERAMIC AGA RANGE UNDER TEST AT THE BUREAU OF STANDARDS

of Standards with an Aga range whose "innards" are fire clay indicate about the same performance as with the standard cast-iron magazine and firebox. Experiments are continuing in an attempt to substitute ceramic material for the metal lids, whose thickness makes them a large reservoir of heat. The complete change from cast iron to ceramic products would save about 1,100 pounds of metal for each range manufactured.

# DEATH IN LIFE

By ORVILLE T. BAILEY

To however great an extent growth may blend with senescence, yet growth itself is a building up, an advance toward the pattern of the intact adult organism. It might appear to follow from this that each of the component parts of growth are in themselves progressive. When the series is analyzed, however, it soon appears that some of the processes, considered alone, are not so; among them are sequences which involve the death of some or all of the cells concerned. Death enters here and there into growth as gold thread is woven through a tapestry to accent the pattern. Here death becomes indispensable to life; without death of this kind, the process of normal growth as we know it would be impossible. In some instances, the sequences are similar to those involved in repair of injury due to external causes, but here they are directed toward the attainment of a normal pattern. Others are of a different character from those in reaction to injury.

How does it come about that death and life, so often regarded as antitheses, are here operating together in order that an objective may be attained? There are many ways in which the two are interdependent; we choose three general classes for study and comparison. In one of these groups, certain substances essential for the body as a whole are produced by the death of cells and transformation of the dead material into the substance required. In the second group, cells are produced by a series of differentiations. These cells are so specialized that they no longer divide. After a time they die; replacement is possible only by repetition of the series of differentiations. In the third group, a defect is created by the death of particular cells; this is followed by repair of the defect in such manner as to lead to the creation of the normal tissue pattern.

## Skin

The first of these three arbitrary groups, that in which essential materials are built up by death of cells, is illustrated especially well in the production of the protective outer layer of the skin and in the formation of nails and hair. Figure 1 shows the normal pattern of the human skin. While there are certain minor differences in its structure in different regions of the body, the fundamental tissue plan is the same everywhere. The pattern is composed of cells which carry out the function of the skin important to the body as a whole and of cells which support and maintain the cells of the first group. The inner portion of the skin (at the bottom of Fig. 1) is composed of connective tissue cells, fibers produced by them, and blood vessels. This is a portion of the tissue pattern which is concerned with support and nutrition of the cells which form the outer layers. The layer is sharply separated from the layer of covering cells. Growth is confined to that region in which the two layers come into contact. The cells nearer the surface die; they are not in contact with a tissue to furnish support and nutrition. They die, however, in a special way, or, rather, in the process of dying they are transformed into keratin, a firm, horny substance which forms the outer layer of the skin. This material keeps the tissue fluids in and foreign materials out. There are very few bacteria which can enter the skin so long as the keratin layer is unbroken. Keratin, which is built from the dead bodies of cells, is essential for the maintenance of the body as a whole. It is, therefore, an instance of the participation of death in life.

If this is the case, then there must be more than one way in which cells die. All cells die when life of the organism as a whole ceases; most cells die at intervals in the life of the individual and are replaced by others of their kind; only the cells of the skin are changed into keratin. The full explanation of this peculiar method of cell death is by no means known but the successive steps by which it is accomplished have been observed. All the new cells are formed in the inner portion of the epidermis since the cells farther out no longer have the capacity for

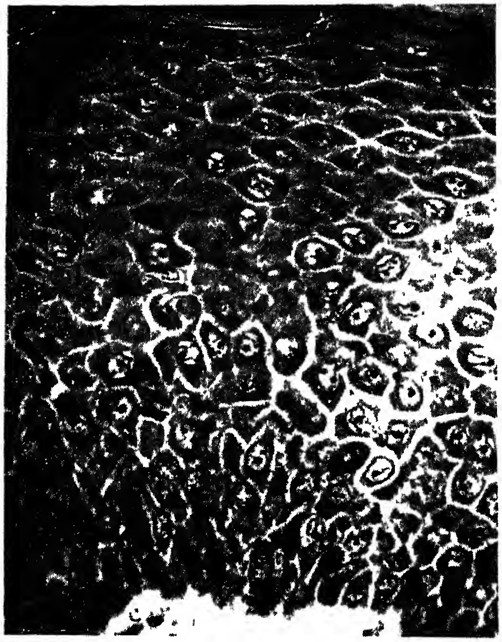


FIG. 1. APPEARANCE OF NORMAL SKIN AS CELLS ARE FORMED NEAR THE LAYER OF CONNECTIVE TISSUE, BOTTOM, THEY PUSH UPWARD THE OLDER CELLS WHICH ARE TRANSFORMED INTO KERATIN, TOP.

division. As the process of cell division continues, the older cells are pushed outward, farther and farther from the supporting cells beneath. This is accompanied by the death of the cells and their transformation into keratin, a transformation which is complete before the surface of the skin is reached. The process is first detectable in cells just above the growing region. In the cytoplasm, irregular, dark staining granules of keratin make their appearance. Gradually, as the cell is pushed upward, the droplets enlarge, and at the same time the nucleus becomes more and more pale. Finally, the nucleus is lost altogether and the cell is dead. Meanwhile, the granules of keratin have come to occupy the whole cell and have been united into a single mass. The outer layers of all skin are made up of cells thus transformed into flat sheets of keratin, which are the ghosts of cells once living. When one of these sheets is placed in a solution of a strong alkali, such as sodium hydroxide, the material separates into parts, each of which has the outline of the cell from which it came.

It goes without saying that bits of the keratin layer rub off from time to time and must be replaced. Keratin can be produced only in this way and the cells necessary for the process can be provided only by the actively growing inner layer. The sequences must therefore be repeated again and again —cell division, development of granules, and finally, transformation of the whole cell into keratin.

One of the strangest aspects of this situation is the relation of the amount of keratin produced with the requirements for it. When much is lost, much is produced. When little is rubbed off, then just that much is formed. In certain places and under special circumstances, the width of the keratin layer is increased. If some special region of the body is subjected to long continued rubbing and irritation as, for instance, in a region irritated by an orthopedic brace, there is an increase in the amount of keratin on the skin below; this returns to normal when the source of irritation has been removed. On the palms and soles, there is a much wider layer of keratin than elsewhere on the body surface. These regions are the ones most subject to the endless little injuries which are a part of our daily experience. Yet that is not the whole story, because the keratin layer on the palms and soles, even before birth, is thicker than that of the skin elsewhere. The production of keratin depends upon cellular death. If growth is to be regarded as the attainment and maintenance of a series of patterns, then death is here a necessary part of growth.

Keratin is produced over the entire body surface. In addition, the skin cells become slightly altered in certain regions and substances related to keratin are produced. They differ from it, however, in distribution and in composition in such ways as to serve different functions. This gives an opportunity to judge in what degree the process of cell death is specialized and how certain apparently minor changes may affect the end results.

### Nails

The nails (the process being the same on the fingers and toes) are formed by a particular group of cells of the epidermis. The layer of cells which covers the skin and which gives rise to the keratin coating by means of a process of death in life, is directly con-

tinuous with the cells at the base of the nail and these with the cells beneath the nail bed. At the tip of the finger the cells beneath the nail again are continuous with skin which is identical with that covering the rest of the body. The keratin layer blends with the nail at its base. From these relationships it is clear that both materials are formed by the same layer of cells, the region of the nail bed only being a somewhat specialized and therefore slightly altered portion. The way in which the keratin layer of the skin and the nails are related would suggest also that the two substances are of similar character, a supposition borne out by chemical analysis and by examination at higher magnification.

The nail substance is formed at the base of the nail. There is at this point a plate of cells somewhat thicker than that of the nearby skin. Here the cells of the deeper layers have the details of structure usually seen in living, growing cells (Fig. 2). The presence of frequent mitoses confirms the activity in growth of the cells in this region. The deeper cells continue to divide and the older ones are pushed away from the layer of supporting tissue toward the region which is to be the nail itself. As the cells are pushed outward, closely packed fibers make their appearance. The fibers consist of a chemical substance peculiar to the nails. They are at once the counterpart of the droplets which make their appearance in the early stages of keratin transformation of these cells and the visible expression of the variations which lead to the differences between nail and keratin layer. The nail can be separated into plates by the action of strong alkalis, just as is the case with keratin. Each of the plates is derived from one cell whose shape it retains.

As has been pointed out, the nail substance grows from a special region at its base and it slides over the layer of cells beneath as the nail extends toward the finger tip. They probably do not contribute in any way to the development of the nail, although some investigators believe that the later thickening of the nail is due to these cells. Anyone who has "lost" a nail as a result of an accident is well aware that replacement must come from the base.

The growth of the nail is a continuous process of death in life. Cells at the base are produced by mitotic division of other cells; these cells are transformed into nail substance; other cells are formed and the process is repeated, with the result that the nail is steadily pushed forward. By this means, the nail reaches the end of the finger, beyond which it finally extends until cut or worn off. The sequence begins before birth and continues throughout the life of the individual. This is only one of many forms of growth which are necessary for maintenance as well as for development of the organism.

### Hair

The nails, as has been pointed out, are the results of a process similar to that by which the outer layer of the skin is built up but characterized by certain small variations from it. The difference in structure of the

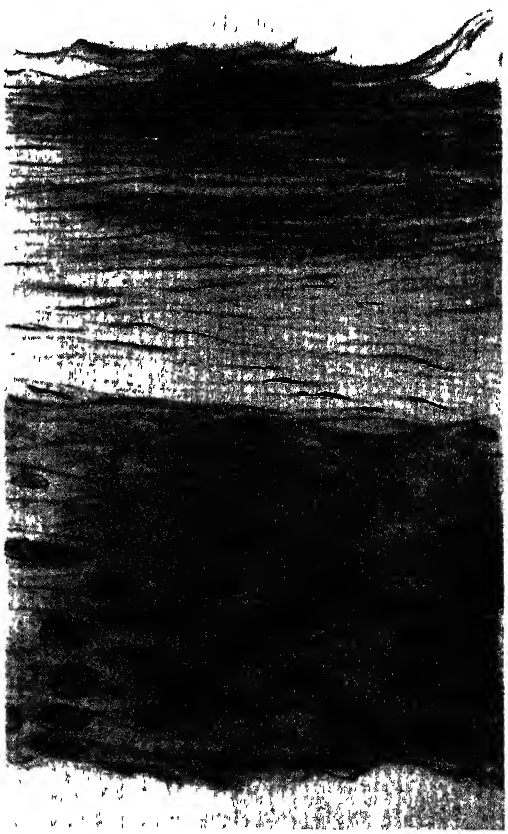


FIG. 2. A HUMAN FINGER NAIL
THE DEATH IN LIFE PROCESS OF BUILDING OF A NAIL IS SIMILAR TO THAT OF THE SKIN'S OUTER LAYER.

nail and skin covering is the result of these variations in distribution of the active cells and in the manner of cell death. The layer of the epidermis in which cell division takes place forms other structures by variations of much the same degree, though qualitatively different.

The minute structure of hairs differs in very few particulars, whether one is removed from the scalp, face, or elsewhere on the body. Each hair develops from a pouch of cells which is directly continuous with the epidermis and is a specialized infolding of this layer, the hair follicle. Cells continuous with actively growing portions of the epidermis line the sides of the follicle and cover a nest of connective tissue at the base (Fig. 3). The cells at the sides of the follicle produce a series of sheaths for the hair; those covering the mat at the bottom are the ones which give rise to the hair proper. These latter cells grow rapidly, as shown by the presence of numerous mitoses. The multiplication of these cells results in pushing older cells upward, farther and farther from the connective tissue. This is a situation strikingly similar to that in which the nails and outer layer of skin are produced. In the cells which have been pushed upward, the nuclei begin to shrink. At first they stain darker than usual and fail to display the normal nuclear detail, a sign of cellular deterioration. Later the nucleus can be made out only as a pale oval area or not at all; the cells then are dead. At the same time, the cells undergo a transformation somewhat similar to that in the two other tissues considered. Granular material can be made out in the stages of this process only in thick hairs, such as those of the eyebrows and beard. The granular material seen in these hairs differs chemically from that formed in the skin and nails, as determined by its reaction with several types of dyes. The cells shrink apart in some places and air fills the gaps among them. It is to these minute bubbles that the glint of the hair is due. Before the hair reaches the surface of the skin, all of its parts are dead. Yet so long as the hair remains, the traces of its cellular origin can be easily shown. When it is placed in concentrated sulphuric acid, the hair breaks up into portions, each of which is a shrunken, flattened, dead cell, and clearly recognizable as such. The mature hair is only growing at its base in the follicle For this reason, hair cannot be produced if the follicle is destroyed.

It is important to bear in mind that the processes just described are quite different from those involved in the formation of intercellular fibers. The most recent evidence in regard to the formation of intercellular fibers in connective tissue indicates that the cells of this tissue secrete a dead colloidal material into space between them. Then, as a result of factors not yet understood, these materials jell in much the same way that gelatin does. Since examination of the collagen molecule, of which these fibers are composed, shows it to be shaped like a rod much longer than it is wide, the result of joining myriads of these molecules together is a thread-like structure. The factors concerned then are physico-chemical and mechanical. The cells concerned do not die. They produce intercellular material without contributing anything to it which was once alive (even though it was once within the cell). Each individual cell retains the capacity for reproduction. Replacement, therefore, does not come from a special layer of cells to which the power of multiplication is restricted. In contrast, further growth of hair, nails, and skin covering can be carried on only from a layer at the base which is in contact with tissue specialized for its support and nutrition.

This is the first type of death in life to be discussed. Other examples of this type can be found readily enough under conditions both normal and pathological. One which suggests itself at once is the formation of the horns of cattle. But this is not the only way death serves the purposes of life.

## Blood

In certain tissues, particular cells divide over and over again, each division being accompanied by a greater specialization of structure and a lessened capacity for growth. The end of such series of transformations is a cell well adapted to perform a complex function but unable to perpetuate its kind and even to sustain itself. Death of these cells inevitably occurs; death in life, for

FIG. 3. A HUMAN HAIR
WITH ADJACENT CELLS. EACH HAIR IS PRODUCED THROUGH A CONTINUOUS PROCESS OF CELL DEATH.

other cells are ready to take their place so long as health continues. This replacement accordingly must be from the actively growing cells in which the series of differentiation has not yet begun or is at most only partially completed. The series of differentiations must be repeated over and over again from the beginning of life to old age.

An example of this type of death in life is afforded by the cells of the circulating blood. The steps in the case of different types of blood cells are different in many respects but the general sequences are the same. For this reason, the present discussion will be confined to the red blood cells. In the bone marrow, where the red blood cells are formed, there are large cells which appear relatively little differentiated by the criteria usually applied to determine this point. They have no recognizable specialized structures in nucleus or cytoplasm, and their great capacity for growth is shown by the numerous mitotic figures.

As these cells divide, one notes that the daughter cells are sometimes identical with the parent. Others, however, are not quite like the cell from which they took origin—in other words, some degree of differentiation has occurred. Furthermore, when differentiation makes its appearance, the variations are not all in the same direction; that is, there are differentiations in several directions. The proximate causes of these separate variations are almost entirely unknown. We can describe them but we cannot predict them or alter the direction under experimental conditions without altering the remaining bone marrow. Various types of blood cells result, depending upon the direction of differentiation at this point.

One of these groups develops into red blood cells. The daughter cells are smaller and more regularly rounded than their parent. These cells go through the process of mitotic division several times. Each time the nucleus becomes more and more compact. At the same time, a yellowish material appears in the cytoplasm, which is the hemoglobin, the carriers of which the adult cells of this series are destined to be. Hemoglobin appears red only in large masses (as in the blood); examination of tiny particles establishes its yellow color. As the processes of cell division and differentiation go on, the nuclear material becomes condensed into a dense mass. When the cells reach this stage, division still continues and little differentiation appears which can be detected with the microscope. There must be some process of this kind going on, however, because after several such divisions, the capacity for mitosis is lost. Then a curious step occurs which is hardly to be matched in the maturation of any other cell in the body. The nucleus is

expelled through the outer membrane of the cell. This stage is regarded as the adult red blood cell and is the form which enters the blood stream.

In this series, we do not know where life ends and death begins. Death enters the picture somewhere along the line of this series of transformations. You can put the transition from life to death anywhere you like. This is one of the places where the ordinary definitions of *life* and *death* are insufficient. It is in investigating just such situations as this—situations in which accepted definitions and theories must be strained if they are to fit at all—that new discoveries are to be expected.

If the mature red blood cells, living things or lifeless mass, are not able to progress, they must disintegrate. Nothing which in nature is living can remain static for long. Some of them are taken up by certain cells of the spleen. The red blood cells at this time are dead, for it has already been mentioned that no cell engulfs another cell which is a part of the same organism unless the cell engulfed is dead. Many red blood cells also disintegrate while still in the circulating blood and the fragments are removed by cells which pick such materials from the blood stream as a street cleaner does refuse from the street.

In spite of all the various stages which must be passed before the adult red blood cell makes its appearance in the circulating blood, and the various methods by which the cell may be removed, the number of red blood cells remains almost the same so long as a person is in normal health. External circumstances make some difference, for the number of red blood cells in the blood of a man who has spent his life on a high mountain is a little greater than that of a man who lives at the seashore. Yet let the man who has lived at the seashore go to live on a mountain and he will, after a time, have an increase in the number of red blood cells in each unit of blood. This is related to the decreased amount of oxygen in the air at high altitudes. Once this change is established, the new level is maintained so long as the external conditions are not again upset.

Even where there is a tremendous loss of red blood cells in a short time, as in hemorrhage, the level of red blood cells returns to normal very quickly. If a man gives a transfusion of blood, his red cell count is normal in less than a week. Yet, when diseases of many types make their appearance or the loss of blood occurs so often that the mechanism for new blood formation breaks down, then the level is changed, usually to a level lower than normal. So it comes about that the red blood cell count is of great value in determining the presence and progress of many illnesses.

How is it, then, that such a level is maintained? In the bone marrow, there are mature red blood cells and their ancestors in one stage of differentiation or another. The bone marrow of a normal individual shows all these stages at any given time. When the primitive cells divide so as to give rise to more differentiated offspring, not all the cells proceed at once to further differentiation. Some remain in a resting state at various points along the way. When a sudden need appears, many more red blood cells can be produced without the lapse of time which would be required if the whole series of differentiations had to take place from the beginning. This is one thing which makes the response so rapid.

But what gives the signal for the increased production of these cells? When the blood contains less oxygen and more waste material than usual, more red blood cells appear in the circulating blood. This is the case with the man going from seashore to the high mountains; it also happens in certain forms of heart disease. This would fall into the class of chemical stimulants to tissues. When the whole story is told (if it ever is) such chemical stimulants will play a large part.

These facts at once suggest that there are several points at which disease may interrupt the normal sequences. The bone marrow may not be able to form more cells; the cells may be destroyed too fast either in the spleen or in the circulating blood; or they may be themselves defective. The red blood cell is the product of a process of death in life. This physiological death must occur in just the right manner and at the right time for health to continue.

It should be pointed out that the situation in the red blood cell is quite different from

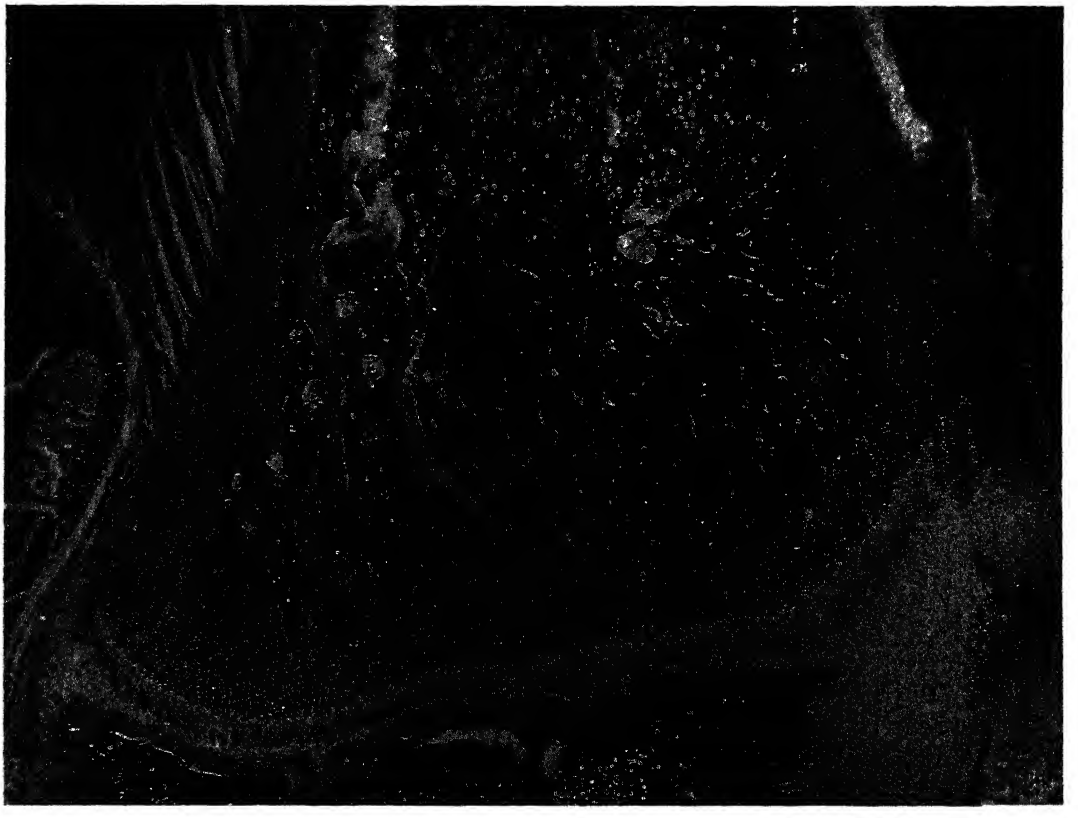


FIG. 4. A NORMAL GROWING BONE
GROWTH OCCURS IN A SPECIAL REGION NEAR BOTTOM OF FIG. ABOVE IS COMPLETED PATTERN OF NORMAL BONE.

that of the adult nerve cell. The nerve cell is also at the end of a series of growth processes and, in its mature state, it cannot reproduce its kind. The difference lies in the fact that the nerve cells survive throughout life. When they die they are not replaced and the functions which were theirs are lost irretrievably. The capacity for growth is in inverse ratio to the degree of specialization. In both the nerve cell and the red blood cell, specialization has been carried to an extreme degree. There is no mechanism for the replacement of the nerve cell, which remains living but not growing all through life. A very complete and delicately adjusted mechanism exists for the replacement of the red blood cell, which is already dying or dead when it begins to function.

### Bone

The sequences of growth discussed up to this point have illustrated two of the ways in which the death of certain cells are a part of the growth and maintenance of the normal individual.

We turn now to consider a third way in which death enters indispensably into growth. In this case, death comes to a particular group of cells; a defect is created, the repair of which leads to the formation of the normal tissue pattern of the organ.

This curious process is best exemplified in the formation of certain bones, especially the ribs and those of the arms and legs. These bones grow in length only at certain particular regions which are found exclusively at those points where bone and cartilage join. The softer, gristly cartilage, uniform to the unaided eye, is transformed bit by bit into the harder bone, the marrow species of which are easily seen without the aid of the microscope.

Figure 4 indicates the appearance of growing bone as seen microscopically. The bone

is divided into bands between which are the marrow cells. There is a thin line of cartilage at the top of the illustration. Here are two different tissue patterns, then, and our concern is the manner in which one (cartilage) is transformed into the other (bone). Between the two, there is a zone in which this transition is brought about by means of a series of steps which must be carried out in a definite order if normal bone is to be formed.

The first of these transformations is in the cartilage cells. They divide in such manner as to produce straight columns of close-packed cells, like the rows of soldiers in eighteenth century military formations. So far we are dealing with a progressive growth process, for it is one in which new cells are being formed from a smaller number of older cells. But at this point a form of cellular death intervenes. The nucleus of each cell shrinks, the cytoplasm breaks up and the cell is dead. This does not indicate that growth has ceased or has become in any way abnormal. On the contrary it is an essential step in the creation of the pattern of normal bone. Meanwhile, other cartilage cells are formed, and the process is repeated over and over. It is as though the soldiers at the end of the column were constantly being shot and replacements were taking their place at the rear at exactly the same rate. The loss of the soldiers at the front would leave a vacant place unless the column moved forward or the enemy moved in and filled the space. In bone formation this gap is filled by the opposing forces, which then bring about a new order which is the tissue pattern of bone.

The repair of the defect follows the same sequences as those involved in the repair of any injury. Capillary blood vessels grow into the place left vacant by the death of the cartilage cells. The capillaries have as their close companions cells similar to those of connective tissue. As a result of this growth process, the two groups of cells are brought into contact with the intercellular material of cartilage. This latter substance has received, meanwhile, a certain amount of calcium. The actual conditions which lead to the deposit of calcium here are obscure as yet.

A word should be added concerning the cells which accompany the blood vessels and which come to lie against the calcified material. These cells are very closely related to the ones in connective tissue which form such things as collagen fibers. What determines the type of intercellular material to be laid down? One of the determining factors is the kind of material with which the cell is in contact. It is known that calcium is sometimes deposited in diseased areas for reasons largely unknown as yet. Cells which normally form collagen may produce bone from these abnormal calcium deposits. Bone is then formed far from any normal bone or source of special bone forming tissue. But contact alone is not enough for oftentimes the two are in contact, yet no bone is formed. There must be other factors, either in the cell or in the cell's environment, or both.

The development of the pattern of bone, then, depends upon the creation of a defect ever repaired and ever advancing. When the gap is finally closed, the bone grows no more, as is the case when the bone is fully developed. If it were not so, we would all be giants There is this paradox that when death (of a sort) ceases, then growth (of a sort) ceases.

Consider the intricate relationships of all these processes, some known, many more hardly guessed at. If one fails, then the pattern of bone cannot be attained, whatever happens to the others—whether they stop or whether they go on. It is extremely difficult to unravel the contribution of each one. What starts it going? What regulates its rate? What happens to other growth processes when it alone is stopped? Methods for studies designed to answer these questions are not easy to find in most instances. Curiously enough, we have at hand a method for studying what happens when only the process of death of the cartilage cells is stopped. This is provided by study of vitamin D deficiency which leads to rickets. In this condition, the cartilage cells multiply, but do not die. There is no defect; there is no repair, and consequently, there is no new bone. The evidence obtained from the study of vitamin D deficiency (rickets) besides giving an indication of the way in which the vitamin is used, offers strong confirmation for this interpretation of bone growth, and,

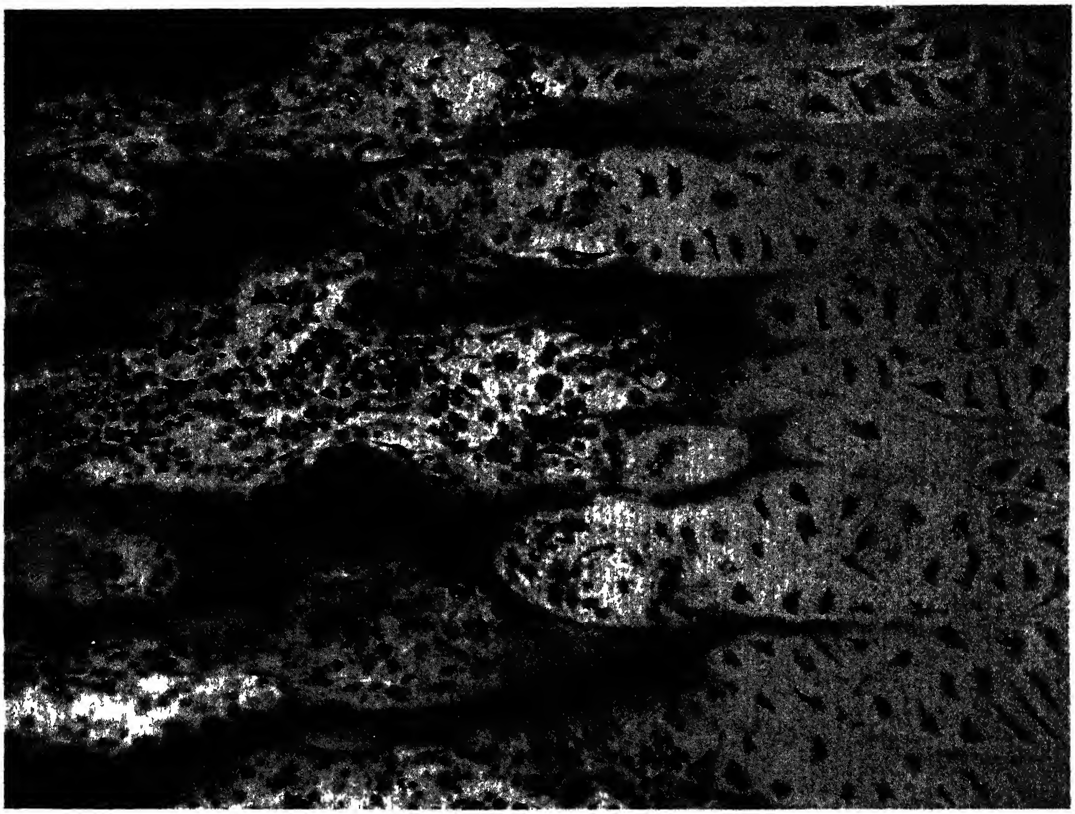


FIG. 5. REGION OF ACTIVE BONE GROWTH
CELLS DEGENERATE AND ARE REPAIRED BETWEEN THE CARTILAGE, RIGHT, AND THE DEVELOPED BONE, LEFT.

incidentally, for the importance of this third method by which death participates in attainment of a normal tissue pattern.

In rickets, the specific effect is the suppression of the degeneration and death of the cells in the cartilage columns. One sees in Figure 6 that the cartilage cells are continuously produced; they differentiate and reach maturity. There the sequences stop. Since the production of new cells is not interrupted, great masses of cells accumulate in distorted columns. The capillaries also appear not to be primarily affected by rickets. Yet as the result of the failure of one specific group of cells to degenerate—because of the suppression of one of the forms of death in life—bone growth ceases. It is curious to think that some one substance should preside over a process of degeneration and death which is essential for the attainment of a particular normal tissue pattern.

When vitamin D is restored to the diet or one of its substitutes made available, repair begins almost immediately and progresses very rapidly. The first evidence of repair is the degeneration of the cartilage cells at the margin nearest the bone. Capillaries at once enter the defect. Bone formation then proceeds through the usual sequences and the normal pattern involves laying down of calcium at the sides of the degenerating cartilage cells; this is resumed also as the capillaries begin to penetrate the defect. Within a few days, however, all traces of the changes due to rickets have disappeared.

## The Permanence of Living Systems

What is death, anyhow? To this, we shall never know the answer until we know wherein lies the difference between the inert products of the test tube and the living cell. And then there is another question—why is death a biological necessity? With this question, there can be some start toward an

answer; a start taken with the full realization that it is only a crude beginning in the search for a complete answer.

At the time when life began on this planet, there must have been something which corresponds to our notion of a cell. We do not wish to imply that this hypothetical first living system had an organization, a structure, corresponding in many respects with cells as we know them today. There is nothing more certain than that biological structures change with time; it is far less certain to what extent and in what direction this goes on. The point which is relevant here is that it is probable that at sometime in the earth's history, a living system developed—how or why there is no way of telling.

It is possible to determine something in regard to the permanence of a living system by the study of the growth of cells in the laboratory. The cell is the unit of life as it is the unit of growth. It has within itself the capacity to perform all the functions which are regarded as the peculiar property of living things. Can cells under favorable conditions continue to grow indefinitely, or does the pattern of the cell finally break up? The classical researches on this problem are those of Carrel. He began the problem as soon as a method was available for cultivating and maintaining cells outside the body. This method of *tissue culture* provides a means by which fragments removed from any organ may be grown in an appropriate nutrient medium. The cells multiply; as the amount of tissue enlarges, portions can be removed and recultured in the same manner.

It occurred to Carrel that the permanence of the living system could be studied by this technique. Accordingly, on January 17, 1912, he removed a piece of heart from a chick embryo. At first, the fragment of heart tissue continued to beat in the tissue culture, an observation which indicated that some of the heart muscle fibers were growing. Microscopic examination, however, showed from the beginning that there were many connective tissue cells among the muscle fibers. Gradually the connective tissue cells overgrew the more slowly advancing and more specialized muscle cells as weeds overgrow the flowers in a neglected garden. After a time, a pure culture of connective tissue cells was obtained in this way. From that time to this, subcultures have been taken from the culture of connective tissue cells and maintained in a nutrient medium. There has been no change in the power of growth of the cells in the culture of connective tissue cells and maintained in a nutrient medium. There has been no change in the power of growth of the cells in the culture and no detectable change in their appearance or in their reactions to alterations in the medium in which they are grown. The rate of growth may be even a little greater than when the cells were first isolated. A letter from Dr. Carrel's secretary written May 14, 1940, states that the growth of the culture is as active as ever.

One obtains an appalling result when he considers the total volume of tissue which would have been produced in those 28 years if all the cultures had been saved and used for further cultures. The fragments of tissue under the conditions of the experiment usually double in 48 hours. If none of the tissue had been discarded, the total produced during the 28 years would have filled the whole known universe over and over again so many times that the significance of the figures mean little to human minds accustomed to the measure of things about them. There is no more convincing proof that connective tissue cells have the capacity to reproduce themselves indefinitely unless the environment external to the cell becomes in some way unfavorable. The vital structure of living cells, therefore, is in a sense immortal, for the generation of these cells is far greater than all the generations of man since the beginning of history. Death is not inherent in the organization which is called life; once this is established it continues until external circumstances become such that the conditions required to maintain the organization are no longer met.

Indeed, a moment's consideration will show that in nature there are conditions which offer evidence of the immortality of protoplasm even more striking than that of Dr. Carrel. The first of these is the fact that all forms of life are continuous. Once life appeared, however, it had the capacity to perpetuate itself. It is true that parents die and offspring grow. But this is not a discon-

FIG. 6. TISSUE PATTERN IN RICKETS

SHOWING A LINE OF BONE FORMATION AND THE INCREASE IN THE NUMBER OF CARTILAGE CELLS IN A RAT SUFFERING FROM ACTIVE RICKETS. THIS DISEASE PREVENTS THE DEGENERATION OF CARTILAGE CELLS WHICH CONSEQUENTLY ACCUMULATE IN LONG IRREGULAR COLUMNS. AS A RESULT NORMAL BONE GROWTH CEASES.

tinuity, for the young arise from living cells of their parents. When investigation is carried to the cellular level, therefore, the apparent interruption of the chain of life disappears. All comes from life which existed before.

There is a third line of evidence which indicates the immortality of the isolated living cell in surroundings favorable to its maintenance and development. This lies in the growth of bacteria which are organisms consisting of a single cell. They grow in the laboratory on artificial media at various rates, depending upon the species and the laboratory conditions. As in the case of the cells in Dr. Carrel's tissue culture, each bacterium gives rise to two or more offspring, which are able to repeat the process. Here, again, calculation shows that if each of the bacteria of a given species were placed in a favorable environment that species would soon occupy the whole world. Life ceases only when the environment no longer is of such nature as to supply it with the substances it needs and to remove the wastes produced in its growth. Now we see, not a part of an organism, but a whole creature which is not subject to death as we know it. As Child has remarked in *Senescence and Rejuvenescence:*

> Sooner or later and in one way or another, the organism gives rise to one or more new organisms, which like their parents are at first relatively small and simple, and like it also undergo a process of growth and differentiation. This is reproduction. In some of the simpler forms of reproduction the parent organism divides into two or more parts which constitute the new generation, and there is nothing which corresponds to death in the usual sense. The old individuality is replaced by new individualities, but nothing is left behind. In such cases there is, as Weismann has aptly put it, no death because there is no corpse.

There is a place in the scale of living things at which there is no death. There must be, then, a place where death first appears. There must be an evolution of death.

How it is that death creeps in? In the simplest form of life the whole organism consists of a single cell, its walls everywhere facing the external world. It can maintain itself so long as the requisite substances are to be found in its surroundings. When organisms become more complex, they are composed of many cells, some cells nearer, some farther from the source of materials required. As specialization continues, the requirements become more exacting; the capacity to adjust the organisms to extreme conditions, less. Here, then, is a far less stable system, which carries within itself the seeds of its own destruction. Only those portions go on which have become specialized for the purpose of reproduction. Then in still more complex animals, there appears another form of death—death which affects only special parts and does so in such a way as to build up the normal pattern of the organism—a process of death in life.

When one speaks of the death of a man (or of higher animals) he usually refers to a phenomenon which is a concern of the whole. Certainly, definite proof of survival of cells in many organs may be obtained for hours after life of the individual as a whole has ceased. For instance, direct stimulation of heart muscle elicits a response for a time after death has occurred and rhythmic beats of the heart have ceased. Death, then, does not overtake each part of the body at once when the life of man ends.

Death is the inevitable result of the high degree of specialization of man. Man pays the price of death in order to know and to control his environment. As Child says:

> For his high degree of individuation man pays the penalty of individual death, and the conditions and processes in the human organism which lead to death in the end are the conditions and processes which make man what he is

Without those characteristics for which man pays with death, he would still be as the bacteria. Without death of parts during life, the pattern of many of his tissues could not be created. The evolution of death finds its culmination in the life of man.

# TROY TOWN ON THE HOPI MESAS

By HAROLD S. COLTON

TWENTY-FIVE years ago the writer called attention to the similarity between a drawing incised on the adobe walls of a Casa Grande Ruin in southern Arizona (Fig. 1) and a labyrinth design on certain coins from Crete of the Greek Period (450–300 B C.).[1] Recently he noted that A. M. Stephen reported the same symbol from a rock on the terrace below the Hopi pueblo of Shipaulovi[2] in 1893 (Fig. 2). A visit to this rock again focused his attention on the problem as to the significance of this design in the southwestern United States.

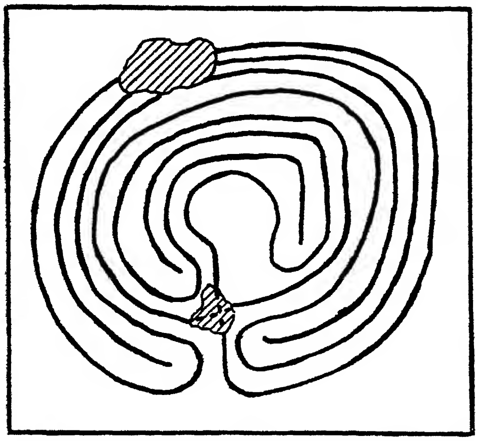


FIG. 1. CASA GRANDE LABYRINTH
A RECONSTRUCTION TRACED FROM A PHOTOGRAPH.

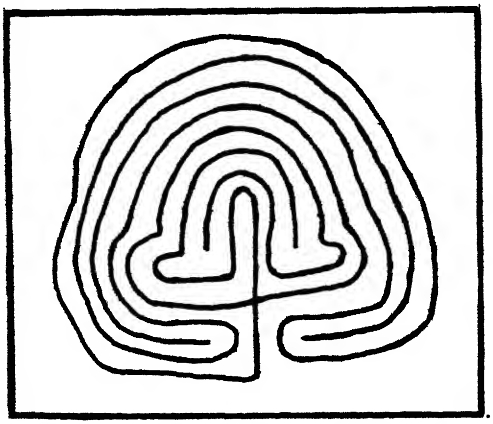


FIG. 2. SHIPAULOVI LABYRINTH
A RECONSTRUCTION TRACED FROM A PHOTOGRAPH.

### TROY TOWN

The design in question, a unicursal labyrinth, has long been known in England as "Troy Town," or sometimes as the "Walls of Troy," and much has been written about it. It seems to have been associated with medieval parish churches in England in the form of a turf maze, of which a few were in existence as late as 1922.[3] Not only is it well known in England, but it is also found all over northern Europe, from Finland to Norway and Denmark, and even to Iceland. As mentioned above, it occurs on Cretan coins (Fig. 3) of the Greek Period (450–300 B.C.), as a glyph scratched on a wall at Pompeii (Fig. 4), and on an early Etruscan wine pitcher (Fig. 5). In a modified form, it has been found on late Roman mosaic floors and medieval cathedrals in France and Italy. It is, therefore, a design widely spread in Europe.

In America the design has a much more restricted distribution. In the Southwest it appears as a glyph at Casa Grande Ruin in the Gila Valley of southern Arizona, as a petroglyph on a rock on the terrace of the west side of the Hopi Indian pueblo of Shipaulovi in northern Arizona, and is not an uncommon motive on Pima Indian baskets and plaques (Fig. 6). In the collection of the Museum of Northern Arizona is a Navajo saddle-blanket with this design (Fig. 7). Not only is the design known in the Southwest, but it is also found far away in the

[1] Colton, Harold S., "Is the House of Tcuhu the Minoan Labyrinth?" *Science*, Vol. 45, No. 1174, June 29, 1917.

[2] Parsons, E. C., "Hopi Journal of Alexander M. Stephen," Vol. 2, New York, 1936, Fig. 516. (In reconstructing the damaged portions of the petroglyph, Stephen made certain errors that can be recognized on comparison with the original drawing. This is also true of Fewkes's figure, *American Anthropologist*, n.s. Vol. 9, 1907, Fig. 35.)

[3] Matthews, W. H., *Mazes and Labyrinths*, London, 1922.

*British Museum*

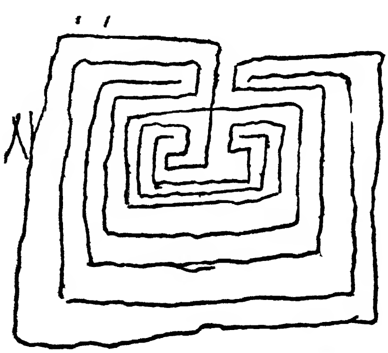
FIG. 3. CRETAN COIN

DATING FROM THE GREEK PERIOD, 400–350 B.C.

mountains of Tennessee, among the people who are of English descent.

### Construction

After the author's earlier paper was published, he received a letter from J. B. Norton, of the United States Department of Agriculture in Washington, D. C., who had been brought up in the mountains of Tennessee. Mr. Norton was familiar with the design, having in his youth played a game called the "Walls of Troy." By means of Figure 8 he shows step by step from A to K how the design of the ordinary, or standard, Troy Town is laid out and developed. However, many variants are common, such as substituting angles for curves or adding more angles; also it is possible to change the cross, by leaving out or adding arms, but such variants are not common in observed historical cases. The Troy Towns on Cretan coins (Fig. 3) and at Pompeii (Fig. 4) have the entrance at the top, while all the northern forms that show polarity have the entrance at the bottom, as shown in Figure 9.

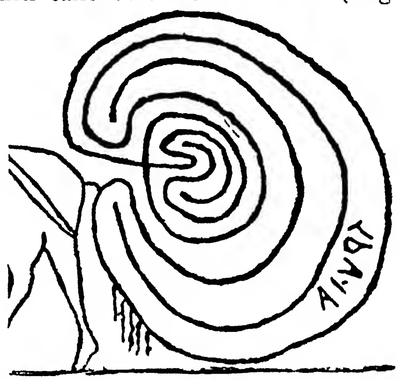


*After Matthews*

FIG. 4. GLYPH

THIS MAZE WAS SCRATCHED ON A WALL AT POMPEII.

As the Troy Town figure is obviously asymmetrical, it does not lend itself to architectural treatment; the Romans, therefore, designed a more or less symmetrical type adapted for use in mosaic pavements (Fig. 10). As this variant accented the cross, it was widely adopted by the architects of the twelfth century cathedrals on the continent of Europe, particularly in France. Moreover, several turf mazes of unknown age in England take this Roman form (Fig. 11).



*After Matthews*

FIG. 5. DECORATION

THIS APPEARS ON AN EARLY ETRUSCAN WINE PITCHER.

Among the various authors who have speculated on the construction of the standard Troy Town, Krause, a German, has shown how it might have been derived from Northumbrian spiral rock engravings. However, no one before Norton, so far as the author knows, has given the manner of construction, which probably is responsible for the persistence of the shape of Troy Town over so many centuries.

### Purpose

Matthews, in his book entitled *Mazes and Labyrinths*, had investigated the use to which the unicursal labyrinth called "Troy Town" was put and comes to no very definite conclusion; nor do the names by which the labyrinth is known furnish any definite clues. Specimens in Somerton and Hillbury in England are called "Troy Town." In Cumberland and Lincolnshire they are called the

"Walls of Troy." A specimen from Wales was called "Caerdroia," Troy Citadel, or City; (Fig. 12). Various Norwegian examples are called "Trojin," "Trojeburgh," "Trojenborg," "Troborg," all of which might be translated as "Troy Town." The specimen on the Etruscan vase is labeled "Truia" (Troy). Thus we have the word "Troy" associated with many of these labyrinths.

The examples found on Cretan coins and the glyph scratched on a wall at Pompeii are definitely associated with the Minoan labyrinth, not with Troy.

In many parts of North Europe, the local examples are associated with neither the Troy nor the Minoan labyrinth. Some in Finland are called "The Giant's Fence," "St. Peter's Game," "Ruins of Jerusalem," "City of Ninevah" and "Walls of Jericho," while one in Iceland is known as "Weyland's House." In Norway, examples are called the "Nun's Fence," "Maiden's Dance," "Round Castle," and "Troll's Castle" (Fig. 13).

Nor do the names by which the Roman architectural form found as mosaics on the floors of continental cathedrals furnish a clue. The mosaic labyrinth in Chartres Cathedral is called "La Lieue," with possible reference to its being a league long, which Matthews states it is not. Other French cathedral labyrinths are called "Chemin de Jerusalem," "Daedale" (referring to Daedalus, the legendary architect of the Cretan Labyrinth), and "Meandre." In these the center is sometimes called "Ceil" (Heaven) or "Jerusalem." These names suggest an ecclesiastical purpose. In the center of the labyrinths at the Rheims, Chartres, and Amiens Cathedrals there are figures supposed to represent the architects of the structures, but this interpretation seems open to discussion. Matthews has pointed out that none of these ecclesiastical labyrinths carries a Christian emblem, nor do these labyrinths appear in the Roman catacombs. In England this Roman variant similar to those in the French cathedrals appears as turf mazes where they are known by various names, such as "Julian's Bower," "Shepherd's Labyrinth," "Shepherd's Race," and "Mizmaze."

Although the labyrinth is associated more commonly in Europe with either Troy or the Minoan Labyrinth, we see that the names throw little light on the purposes of Troy Town, notwithstanding the fact that much has been written about it. However, the persistence with which the symbol "Troy Town" has shown through the ages, over two

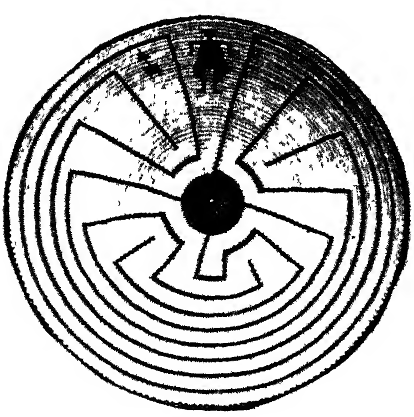


FIG. 6. MODERN PIMA INDIAN PLAQUE FROM SOUTHERN ARIZONA. FROM THE COLLECTION OF THE MUSEUM OF NORTHERN ARIZONA.

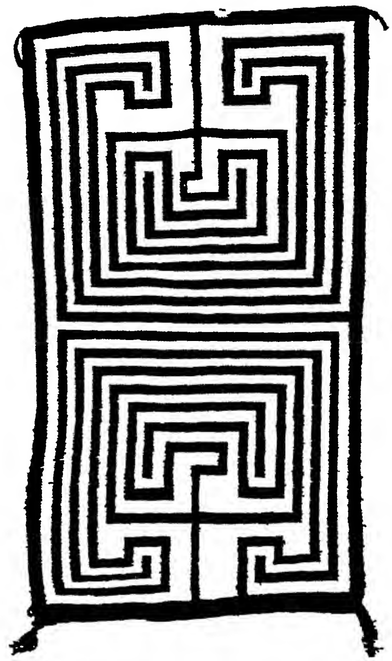
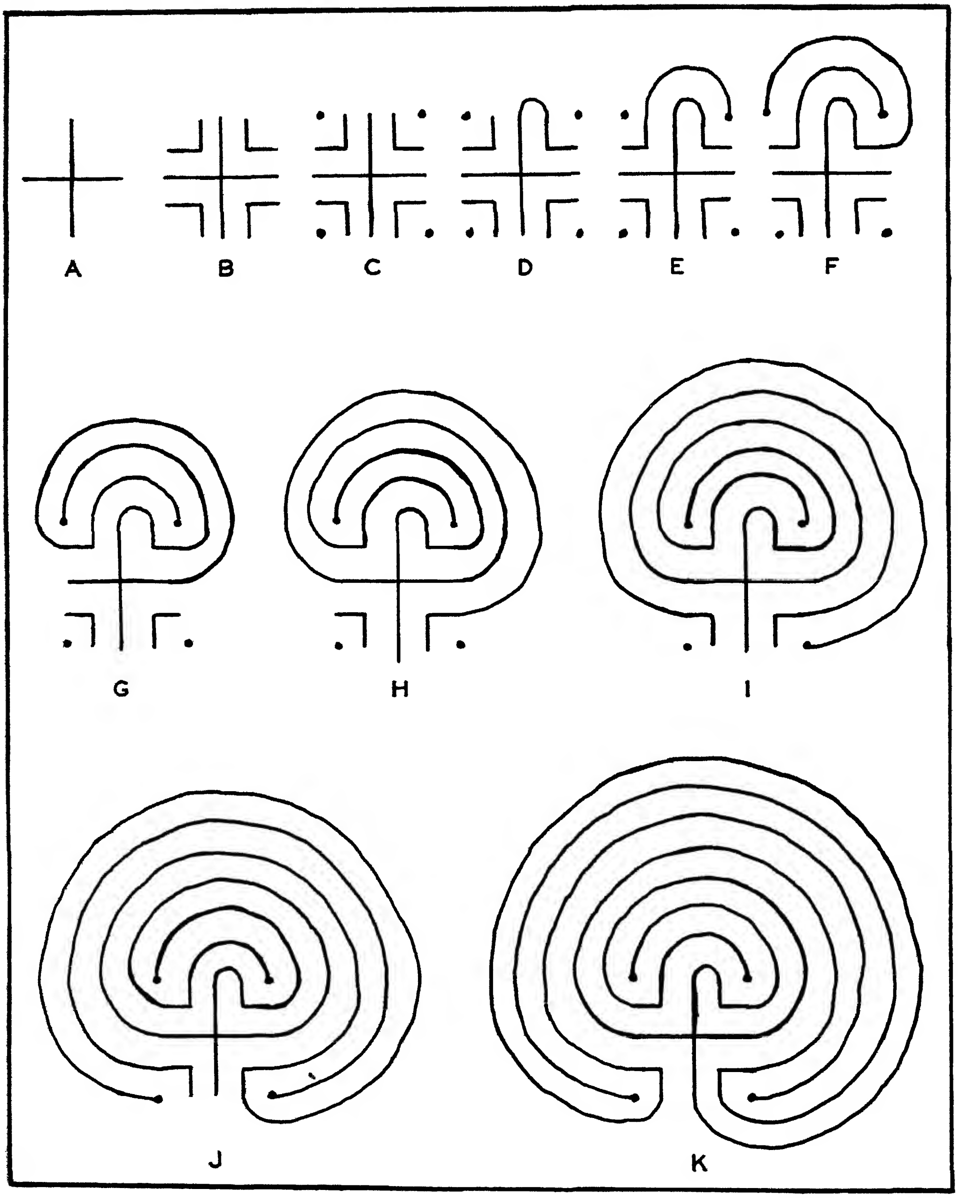


FIG. 7. MODERN NAVAJO BLANKET BELONGING TO THE MUSEUM OF NORTHERN ARIZONA.




*After J. B Norton*

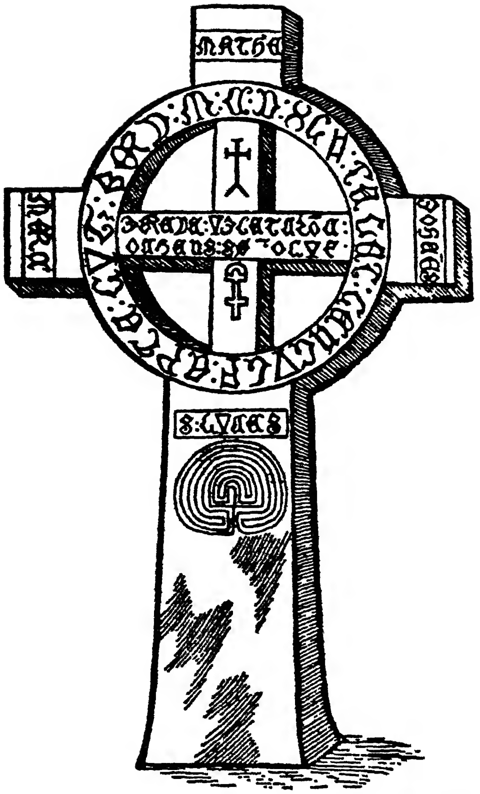
FIG. 8. SUCCESSION OF DRAWINGS SHOWING HOW TROY TOWN IS CONSTRUCTED

thousand years of recorded history, must have something back of it.

In the classical literature are frequent references to the "Game of Troy"; these references go back to the "Lusus Trojae" (Game of Troy) of Roman times. The game seems to have been a processional parade or a dance, sometimes on horseback.

In English literature we have frequent references to "running the maze," but no one tells us just how it is done. In 1870, one Anne Sylvester, writing in "Notes and Queries," laments the fact that the old British "Game of Troy" is becoming extinct, but as she does not describe it we are still left in the dark. If we are to get a solution to this problem, we must probably look to the Tennessee mountaineers.

Although the explanation is highly speculative, Matthews suggests that the Troy Town



*After Matthews from O. Worm, 1651*
FIG. 9. A DANISH RUNIC STONE
BEARING THE DESIGN OF A TROY TOWN LABYRINTH.

Labyrinth may have been a neolithic Nordic Aryan design associated with some ceremony, and that it entered England with the Danish and other Scandinavian conquests, and Greece and Italy with the Aryan migration.

### Interpretation of the Design by American Indians

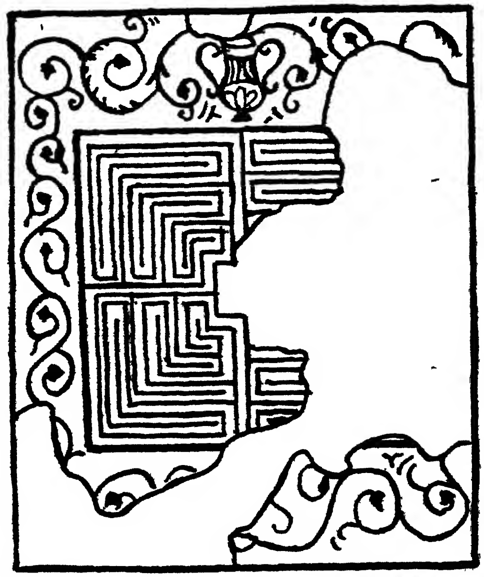
According to Buckingham Smith, the Pima Indians in southern Arizona call the design "Tcuhiki" and describe it as the House of Tcuhu. Tcuoho (Gopher) was a mythical hero who led the Pima clans from the underworld by digging a spiral hole.

After the rediscovery of the Hopi design, the attention of several Hopi Indians was called to the symbol. Edmund Nequatewa interpreted it as *Wu-pa Wi-ki*, a mythical tower built by the women to escape from the men. Alfred Whiting showed the design to Lomaheftewa of Shungopovi, who called it the "Home of Matcito." Whiting later showed it to Don Talayesva of Oraibi, who stated that it was known by two names, the House of Manchito and the House of the Spanish Priests, meaning the Mission of San Francisco at Oraibi (destroyed in 1680), which, legends hold, had a labyrinth entrance. Matcito, or Manchito, was the legendary founder of Oraibi. It would seem that these names apply to any kind of labyrinth, not particularly to Troy Town.

### Troy Town in the Southwest

The southwestern examples of Troy Town at Casa Grande, at Shipaulovi, on modern Pima baskets, and on Navajo rugs are hard to explain, and explanations given now are highly speculative.

At Casa Grande the design is scratched fifteen to eighteen inches above the level of a second floor, which has been destroyed. To have drawn it when the floor was in place, a man would have had to sit. On the other hand, if a man stood on the debris which once filled the first floor room (debris which was probably removed in 1889), he would have been in a good position to make the drawing while standing. This would place the earliest possible date perhaps a century after 1400 A.D., when the structure was thought to have



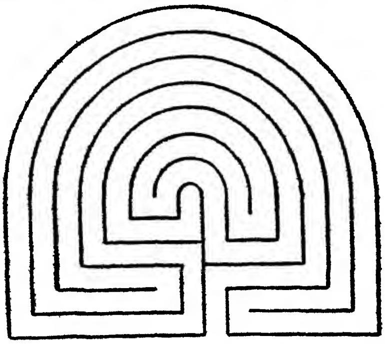
*After Matthews*
FIG. 10. A ROMAN MOSAIC PAVEMENT FROM CAERLEON, MONMOUTHSHIRE, ENGLAND. THIS IS AN EXAMPLE OF THE ROMAN ARCHITECTURAL TYPE.

*After Matthews*

FIG. 11. LABYRINTH, LUCCA CATHEDRAL
THIS IS AN EXAMPLE OF THE ROMAN TYPE FOUND ALSO IN MANY OF THE CATHEDRALS OF FRANCE.

been abandoned. The drawing was first recorded in 1889 by Cosmos Mindeleff, so it could have been made any time between about 1500 A.D. and 1889 A.D. Moreover, it is known that Father Kino said mass in the ruin in 1694, and Father Kino was a German who might well have been familiar with Troy Town.

An unknown priest visited the ruin in 1761 or 1762 and left a drawing of Troy Town on a margin of his manuscript, saying it was a plan supplied by a Pima Indian of another ruin. Apparently Troy Town was as well known to the Pima Indians of the eighteenth century as it is today, so the Casa Grande specimen could have been drawn by one of them. In any case, there was ample opportunity for European contact.



*Matthews after P. Roberts*

FIG. 12. CAERDROIA
THE CAERDROIA IS A WELSH EXAMPLE OF TROY TOWN.

The design at Shipaulovi was first noted by A. M. Stephen in 1893; he said the Hopi called it "Towi-nakvi-ta-ta"; Edmund Nequatewa states that the name does not refer to the labyrinth but to a nearby rock formation which resembles a modern turquoise ear-ring. The design is not engraved, as most of the modern Hopi petroglyphs are, but is pecked in the sandstone rock, as are the prehistoric or early historic drawings in that area. The peck marks are slightly weathered but not much more so than others of the early historic period. As a Franciscan Mission was established at Shungopovi in 1629, less than two miles from Shipaulovi, which

*After Matthews*

FIG. 13. STONE LABYRINTH AT VISBY
ON THE ISLAND OF GOTTLAND IN THE BALTIC SEA.

had a *visita* at Mishongnovi half a mile from the rock, it does not take much imagination to see that there was plenty of opportunity for Europeans to have introduced it between 1629 and 1680, when the Hopi had many European contacts.

Although not impossible, it is highly improbable that so complicated a design could be an independent invention. This is supported by the fact that it does not appear among any of the thousands of southwestern petroglyphs of certain prehistoric age, so we cannot prove great antiquity for any of the known American examples. Therefore, we must conclude that Troy Town in the Southwest could easily have arrived from Europe across the ocean via Mexico by diffusion.

# NEWTONIAN AND OTHER FORMS OF GRAVITATIONAL THEORY

## II. RELATIVISTIC THEORIES

By GEORGE D. BIRKHOFF

*The Larmor-Lorentz-Einstein Framework of Space-Time.* If an impartial observer, supplied with an astronomical clock and a telescope but with no other means of physical observation, were to make observations on the heavens, he would discover a universe in which all of the stars appeared on an equal basis. He would observe that in his individual space and time, the laws of geometry hold, but he would grant that exactly the same laws must hold equally well for any other observer. He would of course realize that light travels with respect to him at a velocity which he might well take to be unit velocity. But he would expect light to travel in the same fashion relative to the space of an observer on another star. In this way he would be led without logical difficulty to a certain space-time framework in which the notion of simultaneity has no longer the same significance for all observers; in particular, events simultaneous for the observer on star $A$ would not be simultaneous for an observer on star $B$, unless $A$ and $B$ are relatively at rest. His final unavoidable mathematical conclusion would be the following: It is possible to set the observations of other observers in agreement with his own by a very simple rule: the clock of any other observer appears to go at a slower rate in the ratio of $\sqrt{1-v^2}$ to 1, and distances in the line of motion are contracted in the same ratio. Here $v$ is the relative velocity of the other star.

Working from electromagnetic considerations alone, Lorentz was led to assume about 1892 that such a spatial contraction takes place in moving electromagnetic systems. Later on, Larmor and he recognized more explicitly the necessity for a similar time contraction. By this means not only were the null effects of the Michelson-Morley experiments fully explained, but a number of other null effects as well.

We may say, then, that the space-time appropriate to the stellar universe and to electrodynamics is this type of "astro-electric" space-time. However, while Larmor and Lorentz saw in the situation a certain disagreeable indeterminacy in the specification of the underlying ether, Einstein was led (1905) to affirm positively that from the very nature of physical law it is impossible to single out one of these systems of reference as being at rest. This conclusion would appear entirely natural to the impartial stellar observer referred to above.

*The Lorentz Group.* The theory so obtained constitutes Einstein's special theory of relativity and amounts to a change from the Newtonian group of motions to what we shall call the Lorentz group, although it might with equal propriety be called the Larmor-Lorentz group. In this type of framework of reference we have a homogeneous four-dimensional framework in which one coordinate is "time-like" and the other three are "space-like," but nevertheless space and time are fundamentally commingled. The two invariants of distance and interval of time of the Newtonian framework are now replaced by a single invariant termed by Lorentz the "local time," which may be written in the symmetric form

$$ds^2 = dt^2 - dx^2 - dy^2 - dz^2.$$

The language of 4-vectors is completely appropriate to this type of space-time, and the mystic equation holds:

$$1 \text{ second} = 186{,}300 \sqrt{-1} \text{ miles}.$$

Today every well-informed physical theorist accepts this type of space-time as fundamental in the electromagnetic domain. The 4-vector language referred to is identical in structure with that of 3-vectors, fundamental in the Newtonian theory.

*The Gravitational Theory of Nordström (1912).* The question immediately presents itself as to how gravitation is to be accounted for in such a modified framework of space-time. The first suggestion is to take over directly the equations written in Part I as characteristic of the Newtonian theory.

However, such a direct transposition is not possible for a reason which can be readily specified.

In the new type of space-time, where the natural independent variable is the local time appropriate to each particle, and the velocity vector has four components instead of three, the "length" of the velocity vector turns out to be 1, while the acceleration vector must be considered as always being at right angles ("orthogonal") to the velocity vector. This makes it necessary to insert a very simple type of additional term in the second of the equations given earlier in the case of the cosmic dust model.

Furthermore the first equation there written, which yields the conservation of mass, may be united with the second equation, by employing the symmetric velocity bivector multiplied by the density $\rho$; this product may be called the energy bivector and is denoted by $T$. Thus the complete equations reduce to only two in the Nordström theory.

$$\boxed{\begin{array}{l}\operatorname{div} T = \rho\ [\operatorname{grad} g - (u \cdot \operatorname{grad} g)\ u], \\ \operatorname{div} \operatorname{grad} g = 4\pi\rho.\end{array}}$$

If we desire to use as model a homogeneous adiabatic fluid or gas it is only necessary to add a pressure term to the tensor T.[1]

The close formal analogy between this relativistic theory of Nordström and the Newtonian theory of gravitation thus becomes apparent.

On this basis Nordström was able to account for all of the usual phenomena of gravitation. The primary reason why the theory was unfavorably received at the time was that it would yield a regression instead of the desired advance in the perihelion of Mercury. The new theory predicted the same shift of spectral lines toward the red as did the later generalized theory of relativity of Einstein.

It is interesting in this connection to quote a note added by Nordström during the final correction of proofs of his article:

> I have learned from a communication by letter from Professor Einstein that he has already occupied himself with the possibility dealt with here, namely, to treat gravitational phenomena in a simple way, and that he has come to the conviction that the consequences of such a theory cannot correspond with the reality. He shows through a simple example that according to this theory a rotating system in a gravitational field undergoes a smaller acceleration than a non-rotating system. . . . However the consequence mentioned indicates that my theory cannot be united with the Equivalence Hypothesis of Einstein. . . . But although the Einstein hypothesis is remarkably ingenious, it introduces great difficulty. . . . On that account it is desirable to consider gravitation from other points of view, and I will permit my communication to serve as a contribution in this direction.

Possibly mathematicians, interested in natural varieties of important theories rather than solely in pursuing the *ignis fatuus* of the "one true theory," will some day give sufficient attention to this simple gravitational theory of Nordström's in order to develop the principal properties of the conceptual universe which he has defined. For example, the two-body problem might well be investigated as it arises in his theory.

Before passing on, however, it is important to note one modification arising in the Nordström theory. In fact, the last equation written, analogous to the Poisson equation in the Newtonian theory, is used to determine the Nordström gravitational potential $g$ as a retarded potential. This means that although the theory is reversible from the formal point of view, it will not be so in actuality. In fact, when time is reversed, the retarded potential becomes an advanced potential, and hence motions are not reversible. In consequence one is led to expect the gradual loss of energy through a kind of gravitational radiation.

*The Equivalence Hypothesis and Tensors.* With reference to a body falling freely in a vacuum toward the earth, gravitational phenomena seem to disappear. It was the fundamental assumption of Einstein's which led to his general theory of 1916 that a like situation holds in all gravitational fields, at least to a certain extent. This conjecture constitutes his celebrated Equivalence Hypothesis.

When the hypothesis is employed in conjunction with the daring but philosophically plausible hypothesis which it suggests, namely, that space-time is conditioned by matter, one is led directly to Einstein's general theory of relativity. In this theory the geometrical ideas of Riemann concerning generalized spaces and the corresponding

[1] That is, $T = (\rho u^i u^j - p g^{ij})$ where the constants $g_{ij}$ are zero for $i$ and $j$ different, and $g^{11} = 1$, $g^{22} = g^{33} = g^{44} = -1$.

tensorial language of Ricci and Levi-Civita play a fundamental part.

*The Associated Group and its Invariant.* The associated group is now the extremely general one which admits all possible continuous deformations of space-time. This means that any coordinates of reference whatsoever may be employed. There has been a tendency on the part of Einstein and others to give this characteristic feature of the new theory of relativity a fundamental philosophical significance. But it must be remarked in this connection that *any* entity can be expressed in terms of such general coordinates. For example, a spherical surface in ordinary space is a very concrete mathematical entity, and yet it can be defined intrinsically as a simply connected two-dimensional manifold with constant Riemannian curvature. In this way we achieve the intrinsic definition of a specific surface in the general language of tensors.

The single fundamental invariant is usually designated by $ds$ and may be called "the element of local time," since it has that significance from the physical point of view. With Riemann, it is supposed that the square of this small element of time, $ds^2$, is measured by a quadratic expression in terms of the small changes of the coordinates. It can be proved that by choosing suitable "normal coordinates," the local space-time framework in the neighborhood of a point (an event) in the four-dimensional world under consideration, takes the same form as that basic in the space-time of the special theory of relativity, namely that defined by

$$ds^2 = dt^2 - dx^2 - dy^2 - dz^2.$$

Here the light-second is taken as the unit of distance.

In such normal coordinates the Equivalence Hypothesis means that bodies move in locally straight lines with locally uniform velocity, while light is also propagated rectilinearly with the velocity 1.

It is a fundamental fact that when such normal coordinates are employed, the same vector notation as before is generally available for expressing the tensor formulation.

*The Gravitational Theory of Einstein.* With these considerations in mind it is easy to explain the general motivation of Einstein's theory.

As in the theory of Nordström, it is sufficient to introduce the symmetric energy tensor of the second order $T$ where the associated matter is conceived of as made up either of cosmic dust or of a homogeneous adiabatic fluid. The equations of motion and the condition for the conservation of mass combine into the single tensor equation div $T = 0$.

Furthermore, if we denote by $G$ the fundamental symmetric tensor of the second order associated with $ds^2$, then the condition that space-time is flat where there is no matter reduces to div grad $G = 0$. The natural way to formulate the condition that space-time is curved by matter is to replace 0 on the right-hand side of the above equation by the simplest possible expression involving the energy tensor of matter $T$.

The uniquely indicated outcome gives the gravitational equations of Einstein:

$$\boxed{\begin{aligned} &\text{div } T = 0 \\ &\text{div grad } G = -8\pi\left(T - \tfrac{1}{2}|T|G\right) \end{aligned}}$$

These equations are a good deal more complicated in explicit detail than they are conceptually. In fact, the theory introduces ten new gravitational potentials instead of the single potential of Newton; and when we use general coordinates instead of the very convenient normal coordinates, the synoptic equations above turn out to contain hundreds of terms.

*Successes and Difficulties of Einstein's General Theory.* There are two remarkably impressive features of the generalized theory of Einstein. The first is that it explains the observed excessive advance of the perihelion of Mercury, which the Newtonian and Nordström theories failed to do, and in addition predicts the bending of light from distant stars by the sun and a shift of spectral lines toward the red, both of which effects have been quantitatively verified through subsequent observations. The second feature is the grandiose suggestion that gravitational and possibly all other physical phenomena merely amount to a kind of generalized geometry. The theory has proved extremely thought-provoking from the point of view of physical theory and from the philosophic standpoint as well.

On the other hand this theory has not entered effectively into theoretical physics. There has been general agreement in the use of the special theory of relativity and its framework as basic for electromagnetism, and (with Larmor) to think of the general theory as a brilliant "auxiliary construct."

Certain difficulties of this theory must be mentioned. In the first place, the Variational Principle adduced by Einstein does not really provide the complete equations of the theory even for empty space, since it is necessary to adjoin a second principle which expresses the condition that the elementary particle travels in a straight line locally, namely $\delta\int ds = 0$. Thus in a strict sense we have *two* Variational Principles instead of *one*, and this fact seems to destroy the significance of the variational property. Of course, as was stated in Part I, it does not seem reasonable anyway to require such a Variation Principle to hold.

Secondly, in a certain sense, the gravitational forces of Einstein are superimposed upon all other forces to the same extent as are the Newtonian forces. The mechanism of the superposition, however, is entirely different in the two cases: In the Newtonian case we simply add on the postulated gravitational forces as further force vectors; in the Einstein case we first express physical laws in the 4-vector language of the special theory of relativity, and then, merely by changing 4-vectors and ordinary derivatives into tensors and "covariant derivatives," we automatically insert the gravitational forces.

*Alternatives to the Einstein Theory.* There have been many papers written with a view to modifying and extending the gravitational theory of Einstein. It was hoped at the beginning that this theory might provide the basis for explaining the apparent rapid expansion of the stellar universe. But it was later seen by Lemaître and others that such an expansion would only be possible if the Einstein field condition (the second equation written above) was lightened. Likewise it was found by de Sitter and others that the four-dimensional framework might be modified in an interesting way by altering the boundary conditions. Such changes leave the Einstein theory substantially unaltered. Among attempts to incorporate electromagnetic phenomena as well as gravitational phenomena in a "unitary field theory" we may especially mention the "gauge-invariant geometry" of Weyl (1919) and Kaluza's five-dimensional theory (1921). In the first of these the quantitative significance of local time $ds$ is abandoned, although $ds = 0$ continues to represent an invariantive condition. Bergmann's recent book says of the Weyl theory that, "in spite of the beauty of the geometrical conception, this geometry has not led to a successful theory."[2] Likewise it is evident that Kaluza's five-dimensional theory and its projective equivalents (Veblen and Hoffman, Pauli), add a fifth dimension "which has no direct physical significance." Here ingenious *ad hoc* hypotheses concerning the fifth dimension yield four new world functions which operate as the basic electromagnetic vector potential.

In this way, a number of different and interesting further leads have been suggested, based on curved space-time. All of them purport to present a geometrical view in which matter appears as a local singularity in a geometric manifold. The technical difficulties to be overcome in their further development seem to me extremely great. There is an undeniable air of unreality about them as well as in Einstein's generalized gravitational theory.

*Some Other Theories.* There have been attempts to obtain a simpler explanation of the crucial phenomena referred to above. For example, in this country H. B. Phillips (1920) tried to deduce the same conclusions from the Newtonian point of view. His simple and ingenious theory has since been rediscovered more than once. Phillips accepts the somewhat vague Principle of Equivalence of Einstein and shows that, by interpreting it conveniently in the space and time of classical physics, it is possible to arrive at Schwarzchild's basic formula, upon which alone all the crucial tests are known to be based. Unfortunately, it would be hard to deny that some of the reasoning is *ad hoc*, being definitely directed towards obtaining this very formula.

Others have tried to find a basis in the

[2] *An Introduction to the General Theory of Relativity* by P. G. Bergmann, with a Foreword by A. Einstein (New York, 1942).

electromagnetic space-time of special relativity. A conspicuous illustration has been the attempt of the English astronomer Milne (1933).[3] To me his gravitational developments seem lacking in cogency; E. A. Milne starts with a homogeneous expanding universe based on special relativity, and it is hard to see how any definite theory of gravitation results from the inherent properties of his model.

In neither the theory of Phillips nor of Milne does there appear a natural analogue of the fundamental Poisson equation characteristic of the Newtonian theory.

*The Relativistic "Perfect Fluid."* The idea of the "perfect fluid" was introduced by me in 1928 but with no thought of using it except against the framework of the generalized theory of relativity of Einstein. My interest in the perfect fluid arose from the fact that it was a satisfactory form of matter from the mathematical point of view, and appeared to afford a possibility for a conceptual derivation of Schrödinger's celebrated "wave equation" of 1927.

It was only in 1942 that it occurred to me to try to construct a gravitational theory in which the perfect fluid was used against the background of the flat space-time of the special theory of relativity. To my surprise I found that the simplest possible theory of this type led to results in complete accord with known gravitational phenomena. It was this new theory which I presented at the Astrophysical Congress in Mexico in 1942. Before proceeding with the consideration of this theory, it is desirable to make clear why the perfect fluid deserves our special attention.

To begin with, let us examine from the mathematical point of view, what type of fluid is worthy of being a model for matter. The model of cosmic dust, used in the Einstein theory, appears invalid inasmuch as such matter can interpenetrate freely, condense on a point, and turn inside out, in the natural course of events!

On the other hand, if we consider forms of homogeneous adiabatic fluid in which there is pressure, we avoid these difficulties, but we run into another difficulty which is equally serious. Such fluid will have a definite disturbance velocity at all densities. If this disturbance velocity is greater than that of light, there is evidently a fundamental difficulty, since it is a basic presupposition that the velocity of light is a limiting velocity. If this velocity is less than that of light, and if two portions of the fluids collide at oppositely directed velocities exceeding this disturbance velocity, then the equations break down. Thus it seems essential to demand that at all densities, the disturbance velocity must be exactly equal to that of light. When we do so, there is obtained the "perfect fluid" with "equation of state" $p = \frac{1}{2}\rho$. For reasons which I cannot enter upon here, it seems certain that no difficulties can ever arise with interacting and colliding portions of perfect fluid, moving in a relativistic framework.

Such a fluid will be almost incompressible, due to the enormous disturbance velocity, and its mass will not be strictly invariable. It is impossible therefore to criticize its structure on account of any thermodynamic argument based upon the strict conservation of mass. As has been kindly remarked in Buenos Aires by my eminent colleague, Professor Enrique Butty, the perfect fluid has a certain analogy with the well-known "luminiferous ether" of Young and Fresnel in which light travels in all directions with the same velocity. There is, however, the basic difference that while the luminiferous ether is essentially static, the perfect fluid is conceived of as only filling part of electromagnetic space-time, and as mobile and dynamic.

*The New Theory.* My theory, like Nordström's, is built upon the electromagnetic frame-work of the special theory of relativity. I start from the perfect fluid as a model and introduce a symmetric gravitational potential $H$ (a tensor), letting $T$ designate as before the symmetric energy tensor of the perfect fluid.

The equations of motion of the fluid are of course written div $T = f$, where $f$ is a force 4-vector which has to be specified. The natural requirement, by analogy with the Newtonian theory, is that the 4-vector $f$ should be linear in the "first partial derivatives" of $H$. Furthermore, $f$ must be automatically orthogonal to the velocity vector $u$, since, as

[3] See his *Relativity, Gravitation and World Structure*, 1936.

has been noted above, the force and acceleration vectors are always orthogonal. Finally, it is natural to require that the gravitational theory shall be formally reversible in character, as it has been in all previous theories. The *simplest* form for $f$ which meets these requirements is then the following:[4]

$$\rho u \text{ curl } H\, u$$

Thus the two equations of the "perfect fluid" theory are obtained:

$$\boxed{\begin{array}{l} \text{div } T = \rho u \text{ curl } H\, u \\ \text{div grad } H = 8\pi\, T \end{array}}$$

The "perfect fluid" theory of gravitation embodied in the above equations not only yields an explanation of gravitation in its first order effects, but also leads to essentially the same conclusions as Einstein's regarding the three crucial second order effects! It seems to me to deserve careful consideration.

There is no difficulty in incorporating the electromagnetic as well as gravitational forces in the new theory. Of course the electrical charge is thought of as invariably attached to the perfect fluid. The form of the electromagnetic force which has to be added to the gravitational force specified in the first equation of the "perfect fluid" theory is of interest, because of its structure. The more important electromagnetic force vector is known to be *linear* and homogeneous in the velocity vector $u$ while the gravitational force vector is *quadratic* in the above theory. This is fitting, in view of the fact that gravitational forces are much smaller. One recalls in this connection a daring speculation of Sir Joseph Larmor's in a section entitled "Are the linear equations of the Aether exact?" of his important work "Aether and Matter" (1900), where he asks: "Why then should not relatively minor phenomena like gravitation be involved in similar non-linear terms in . . . the analytical specification of the free aether. . .?"

It is to be emphasized that the new theory is strictly based upon electromagnetic space-time and is formulated completely in the language of 4-vectors. The development of the theory and its application to the crucial phenomena is an elementary and simple matter requiring only four or five pages of routine mathematical work.

Whether or not these equations can be obtained out of a simple, unified variational principle remains to be seen. I have not as yet had an opportunity to investigate this interesting question. Likewise I have not as yet found time to examine whether or not the theory suggests further experiments, by the aid of which it and the Einstein theory of 1916 might be compared.

*Concluding Remarks.* My primary purpose has been to convey some idea of the intimate formal relation between the grandiose theory of universal gravitation of Newton and certain recently proposed relativistic modifications. It seems clear that the Newtonian theory will always stand as the realistic basis for astronomical calculations. Relativistic theories are likely to be used only in a few cases when large velocities enter and the minute relativistic effects can be observed.

Nevertheless such relativistic theories seem more in accord with the electromagnetic structure of matter than does the theory of Newton. These new theories deserve much more serious attention than they have received, both from theoretical physicists and mathematicians, for they are as yet in a highly incomplete state. For example, it is not even known whether a real analogue of the two-body problem exists in any of them. Furthermore, not one of them is really a field theory in the complete sense of the classical electromagnetic theory of empty space, since all differentiate between the parts of space-time where matter is and void space-time.

One cannot but feel the highest admiration for the solid and permanent accomplishments of the gravitational theory of Newton, and for the splendid developments of classical physics which it inspired. It would be intensely interesting to know how Newton himself would regard the relativistic variants of his theory which have been suggested by modern developments in electromagnetism and modern mathematical formalism.

[4] This notation is not quite complete, since a triadic vector, curl H, is involved. The specific definition is

$$f_1 = u^\alpha \left[\frac{\delta h_{1\alpha}}{\delta x_\beta} - \frac{\delta h_{\alpha\beta}}{\delta x_1}\right] u^\beta$$

# THE NATIONAL ROSTER OF SCIENTIFIC AND SPECIALIZED PERSONNEL

By LEONARD CARMICHAEL

I AM sure that almost every reader will agree that highly trained professional and scientific personnel is a national resource indispensable to the successful prosecution of the war, on the fighting and on the home front. The mobilization of a modern, democratic, industrial nation for total war must necessarily pass through a series of different developmental phases. This dynamic process last year reached an extremely grave point so far as the proper utilization of technical manpower was concerned, and the situation is even more grave today. It is fortunate, therefore, that the instrument of the Federal Government for dealing with this problem—the National Roster of Scientific and Specialized Personnel, which was created a little over three years ago—is now well established in its functions and procedures. At least some of its growing pains are over.

The recognition of the need for this central clearing house, not only for the names of specialists but also for the development of policies and procedures concerning the utilization of specialists, first took concrete form in the summer of 1940 in the organization of the National Roster. The lack of such a mechanism in the last war, resulting in haphazard handling of such personnel, was the principal factor in developing the Roster mechanism to prevent a recurrence of these difficulties. In short, the Roster was created because of the necessity of having an organization specially equipped, in terms of facilities and personnel, to deal with the special characteristics and complexities of the professional labor market. No matter how decentralized their regular labor market procedures may be, other countries, on the basis of similar experiences, have also found it necessary to establish *central* agencies and controls for dealing with professional and scientific personnel on a policy and individual case basis.

The National Roster was established in June 1940 under the joint sponsorship and direction of the United States Civil Service Commission and the National Resources Planning Board. Under authority of the Employment Stabilization Act of 1933, the National Resources Planning Board had been charged, among other things, with developing procedures for the proper conservation of natural resources, both physical and human. To the National Roster was delegated the responsibility of devising effective procedures for carrying out the function of conserving one highly important segment of the Nation's human resources—highly trained scientific and specialized personnel. The charter of agreement between the United States Civil Service Commission and the National Resources Planning Board concerning the setting up of the Roster was approved by the President of the United States.

In creating the War Manpower Commission on April 18, 1942, President Roosevelt stated in his Executive Order that the function of administering the National Roster should be transferred to that Commission. In Section 6 of his Order, the President directed that the National Roster should be preserved as an "organizational entity" within the War Manpower Commission. Since December 1942, the Roster has been an integral part of the War Manpower Commission's Bureau of Placement.

The primary function of the Roster is to provide for the most effective utilization of this country's scientifically and professionally trained citizens in the war. Two purposes of equal importance predominate in the functioning of the Roster: first, the recruitment of skilled professional and scientific individuals for the Army and Navy and all other war work; second, the best possible utilization and hence conservation of this reservoir of human resources. Through each changing phase in the nation's mobilization, the Roster, in accomplishing its functions, has kept foremost its basic purpose of making a proper contact between the right profes-

sionally trained man or woman and the right war job.

Fundamental plans of the Roster from its inception have been to secure as nearly complete registration as possible of all highly or specially trained individuals in the United States in professional and scientific fields which are critical or significant because of war needs. During the three years of its organizational existence, the Roster has developed an analytical punch-card record of the locations, qualifications, and special skills of more than a half million of the Nation's scientists and professional men and women. As of July 1, 1943, the Roster had in its files data on the qualifications of 597,666 men and women who were distributed among 61 professional fields. Of this number 224,133 were physicians, dentists, and veterinarians, who come under the jurisdiction of the Procurement and Assignment Service of the War Manpower Commission. The master punch-card index is so organized in the Roster office that any individual combination of skills or abilities required for particular war needs can be selected quickly and accurately. This selection process is accomplished by the use of electric card sorting procedures.

The Roster has well established procedures for maintaining on a current basis information on registrants, particularly those in the critical fields. This is accomplished by periodic recircularization of Roster registrants with a brief supplemental questionnaire.

As an illustration of some requests made of the Roster for unusually qualified persons, I recall an order placed by the War Department requesting "the names of Americans who possess a knowledge of epidemiology and chemotherapy, are competent in the diagnosis and control of *Endamoeba histolytica* and other protozoan infections, have a knowledge of the Hindustani language, are skilled in the operation and use of specialized bacteriological research apparatus, and have traveled in the tropics." An epidemic had broken out in a tropical island where the United States was building a new air base. The germ carriers were thought to be transplanted Hindus. An hour after the request was received, the name of an available and qualified person was provided, and before the day was out he was on an Army clipper flying to report for duty. Of course, such complex and dramatic requests are not an every day occurrence, but many such have been received and they have been filled.

At the beginning of its fourth year the Roster found its task decreasingly but still actively concerned with the recruitment of personnel, and increasingly employed in attempting to secure the effective reallocation of highly trained scientific workers from less essential to more essential war activities. In the fields of critical personnel shortages the time has passed when individuals can freely move or be shifted haphazardly from one position to another without harming an activity which is nationally important. A significant function of the Roster is to participate in effecting such transfers with the purpose of advancing the war effort. It should be emphasized in this connection that another important function of the Roster, in its consideration of the proper allocation of professional and scientific personnel, is to assist the Army and Navy in securing such personnel to fill technical posts, and at the same time to maintain a sufficient number of such experts in really essential civilian war jobs.

In order to perform its functions, the Roster is organized in three principal sections. First and foremost is what we call the Professional Placement and Evaluation Section, which is concerned with the analysis and evaluation of requests for personnel. This Section also concerns itself with job analyses and the evaluation of all qualifications of available professional workers to meet the specific war job requests that are received before certifying selected lists to prospective employers.

Requests for scientific and specialized personnel are received by the Professional Placement and Evaluation Section of the Roster from Government agencies, educational institutions, private industry, and the Army and Navy. The determinations that the Roster must make as to who shall be certified in connection with each such request require the consideration of many important factors. The first, of course, is the quality and extent of the experience and education of the registrant. In addition, and this

is important, the present employment of the individual is taken into consideration to determine whether he is now filling a position which is also vital to the war effort. If he is serving in a position essential to the country's war effort, as defined by the War Manpower Commission, he will not be certified unless it is determined that he will be more valuable in this new position than in his present one. This determination must be made before an individual's name is certified for another position. As one example, there might be cited the case of the United States Rubber Company, which had been holding up operations of a cartridge manufacturing plant in Des Moines, Iowa, because of its imperative need for a top-notch brass metallurgist it had been unable to locate. The Roster located a number of persons possessing the necessary qualifications and determined which of the several plants in which these persons were employed was in the best position to release one of these men. In this case the plant in question was queried and a friendly release secured for the needed man. Another example would be the case of Vought-Sikorsky in Connecticut, which sought a highly specialized metallurgist to head a new testing laboratory found to be essential to the efficient operation of the plant. Again, through the Roster's resources a highly qualified individual was located and made available, although he was at the time employed in an essential activity. Similarly, the Roster has been called upon to make available highly specialized personnel in the engineering and chemical professions for assignment to Government positions in North Africa as well as to perform secret research work of great importance in connection with battlefront problems which require immediate solution. Once again, the personnel provided were already engaged in essential activities.

For all jobs in the Federal civil service, certification is made through the United States Civil Service Commission. For jobs in industrial establishments, certification is made through the local United States Employment Service office. This cooperative procedure is set forth formally in a United States Employment Service Operations Bulletin. In addition to the above procedures, local U.S.E.S. offices transmit to the Roster the names of professional applicants. The Roster certifies directly to colleges and universities and to the Army and Navy. In the case of the armed forces, the Roster often assists in locating qualified and available persons, who are offered commissions. In this function the Roster acts for engineering and the sciences in a manner comparable in many respects to the Procurement and Assignment Service for Physicians, Dentists, and Veterinarians of the War Manpower Commission. To date, the National Roster has certified over 140,000 names of specialists to various agencies engaged in the war effort, including requests from the Army and the Navy for specialists to be made commissioned officers. More than 10,000 individuals have been directly offered commissions in the Army and Navy from the Roster's rolls. In all such cases the Roster has judged that the individual in question could use his highest skill in the armed services for the work specified.

It is important to point out that Roster lists are not like Civil Service registers. Thousands of highly qualified specialized personnel who registered with us have never been seekers for employment. We once brought out five men who were listed as having salaries of $200,000 or more. We have on the Roster many men who are not hunting for a Government job or for a job transfer. We have tried to create a different point of view. We wanted a complete registration. So the Roster lists are not to thought of as being the same as the Civil Service lists of individuals who are willing to take jobs. The Roster convinced many of the people on its lists that, due to the national need, the individual should take a new war job. We have many, many examples of men who have, I think, without any indirect thought of profit, taken jobs at one-half or sometimes one-fourth of the salary that they have been securing, and I believe they have done so purely out of desire to do a patriotic job in this period of great national crisis.

In order to make the day-in-and-day-out operations of placement in the Roster effective and appropriate to the current and ever-changing national manpower picture in the professions, it has been found necessary to buttress the placement service of our office

with two other special office sections. The first of these is the Professional Surveys Section, which was established in the office of the Roster in order to provide accurate information concerning supply and demand in the professions. It was organized to carry on the work initiated in the Roster by a volunteer Committee on Wartime Requirements for Specialized Personnel set up in the winter of 1942 under the able administration of Mr. Owen D. Young. Through its Professional Surveys Section the Roster assembles available data with respect to existing pools, potential supply, and prospective requirements for scientific and specialized personnel in each field of crucial war service. The Section also attempts to relate supply and demand figures to the rate of production in colleges, universities, and technical schools and, through timely surveys, to appraise the capacity of educational institutions to train additional persons in fields in which shortages exist. The Section maintains liaison with the Professional and Technical Training Division of the War Manpower Commission, the educational world directly, and with such agencies as the United States Office of Education, the American Council on Education, the Advisory Board of the Engineering, Science, and Management War Training course program, the Joint Army-Navy Committee for the Selection of Non-Federal Educational Institutions, and the national offices of the specialized engineering and other fields represented by the Roster.

As a fact-finding service, the Professional Surveys Section is designed to assemble continuously data on the needs of the Army, the Navy, war industry, war research, education, and National, State, and local governments for trained individuals in the professions, sciences, and other specialized fields, and to estimate in quantitative terms the probable total needs for such men in each field.

As an advisory service regarding training programs, this Section, on the basis of facts already secured and to be secured through continuing studies by its fact-finding service, makes available information to those agencies primarily concerned with training programs, as well as to colleges, universities, and technical schools. Thus far, this Section has prepared reports for general dissemination on the personnel situations in physics and engineering and it is now engaged in preparing similar reports in chemistry, geology, mathematics, and the agricultural and biological sciences. These reports are probably the most detailed and factual studies of professional employment ever assembled in America.

The Professional Surveys Section is organized so as to separate into appropriately designated units the responsibilities for surveying the situations in the areas of industry, government, including the military, and educational institutions. The information developed by these units is coordinated and interpreted in the form of reports, analyses, and summary statements. From the first, the policy with respect to surveys has been to utilize whenever possible the fact-gathering facilities of other agencies. Thus, last fall the Civil Service Commission conducted for the Roster a special survey of the employment and need situation in the Federal Government. The United States Employment Service conducted in March of this year, in conjunction with its regular bi-monthly labor market survey, a special survey of the situation in selected professional fields in industry. As a result of this study we have been able to assemble facts concerning the needs for engineers and scientists in 15,000 of the leading industrial organizations of the country. The data provided by these surveys have been of great assistance in evaluating the overall situations in the professions. Due to recent unsettled conditions relating to budget and employment in the Federal Government, we have not yet planned the conduct of a new comprehensive survey of Federal agencies, but instead, by direct liaison with departments and agencies, have accumulated current data in those fields in which such additional information has been necessary.

In the spring of 1942 a number of proposals were made concerning the wartime utilization of our colleges and universities for the training of additional supplies of personnel in critical war areas. Because of specific recommendations for subsidizing professional training, other Bureaus of the Government were vitally interested in the development in the Roster office of a section

that would continuously assemble data on the human and physical resources of the colleges, which would indicate the training potentiality of higher education for specialized war service. This interest provided the principal impetus for the Roster's undertaking a series of surveys of the situation in the departments of mathematics and physics and the schools of engineering in the summer and fall of 1942. In the early winter of 1942, the Joint Committee of the Army, Navy, and War Manpower Commission on the Selection of Non-Federal Educational Institutions requested the Roster to undertake a general survey by separate fields of the faculty, students, and physical facilities of our colleges and universities. This survey was also directed at acquiring data on overall plant capacity, such as maximum housing and eating facilities. The data acquired from these four surveys concerning some 1,800 institutions have served as the basic information used in the selection of institutions and assignment of tentative quotas in the Armed Forces' training programs.

We now have under way a series of surveys of the current situation in several college departments and schools. These are the departments of physics, mathematics, chemistry, geology and geophysics, and the engineering and agricultural schools. All of these schedules have been worked out with the assistance and cooperation of interested and affected agencies. For example, those on physics, mathematics, and engineering are not only calculated to provide current data (which will provide a measure of the effectiveness of the Selective Service student training bulletin, identified as Activity and Occupational Bulletin No. 33–6) but also to provide special information needed by the Armed Forces in the further development and extension of their student training programs.

With few exceptions, the findings of the Roster relating to the critical situation in separate professional fields have been adopted by the Essential Activities Committee and recently promulgated by the Commission as Part II of the National List of Critical Occupations. In general, therefore, the current problems in the professional fields have to do with strengthening measures and procedures directed at securing the best possible utilization of supplies now available for placement, and in appraising and re-appraising the effectiveness of measures designed to increase such supplies during the war. The present personnel situations in the professions do, however, vary a great deal from field to field. For example, in such fields as engineering and physics the shortages of over a year ago have been intensified in spite of the large emphasis they have been given in wartime training programs. The critical situation is largely due to the extraordinarily heavy demands made by the military and civilian government at the same time that requirements of war industry were increasing so rapidly.

In another field—geology—the personnel situation at the beginning of 1942 was one of reasonable balance between supply and demand, with some reservoirs not completely exploited for war purposes and, therefore, the profession was not generally treated as a shortage group. As the result, however, of the lack of any general provision for occupational deferment, a relatively large percentage of the numbers in this group entered the armed services and new supplies from the colleges have all but disappeared. A current study of the situation in this field, soon to be released by the Roster, will show that the situation now has become one of additional need which cannot be satisfied because the supplies are no longer in existence. Thus, it appears that even though geology has now been included on the critical occupation list, it will be necessary to take positive steps to see that additional supplies are made available in this field during the war. Geologists are using their professional skills in the Army and are also engaged in special explorations in connection with the discovery of new sources of water, petroleum, and strategic minerals in this country and in countries now occupied by our troops abroad or cooperating with the United Nations.

It is always important to assist the Army and Navy, war industry, and the agencies concerned with the welfare of the nation in order to make a proper distribution of its technically trained manpower. For nearly two years the personnel situation in the pro-

fessions and sciences has been emphasized to local Selective Service boards by the National Roster. Occupational Bulletin No. 10, containing the first list of critical professional occupations, was issued in June 1942. This list was issued by the Selective Service System upon certification by the National Roster. Even prior to this date, however, the National Roster, through its Military Advisory Section, had been providing assistance to local boards in certifying as to the professional qualifications and essentiality of work of Selective Service registrants in Roster areas. This was a special procedure placed in operation, in the fall of 1941, with the express approval of General Hershey, and the certifications made by the Roster are written on the stationery of the National Headquarters of the Selective Service System and bear the signature of General Hershey. Because of this relatively long history we are informed that many local boards understand and have confidence in the National Roster and regard it essentially as a central placement and assignment agency in the professions.

The number of occupational deferments in the fields with which the Roster deals is relatively large in relation to the total number of outstanding occupational deferments, even though the total number of personnel in the critical professional occupations still in civilian activity amounts to less than one percent of the total civilian working population. As a result of their considerable experience in dealing with registrants claiming professional qualifications, the local boards are now in a position to make relatively accurate determinations concerning occupational status in a majority of cases of registrants in professional fields.

There has recently been established in the National Roster a Professional Allocations Section staffed with employees possessing outstanding qualifications in important professional and scientific fields. Attached to this section also are advisory committees in physics, mathematics, chemistry, and engineering, the members of which serve as consultants to the National Roster in helping to determine policies and procedures and in acting on individual cases of a borderline nature with respect to Selective Service status, placement, and overall utilization problems. There has been operationally identified with the Roster a Committee on Scientific Research Personnel, created by Governor McNutt on March 22, 1943. This Committee is composed of a high-ranking representative from the Army, the Navy, the National Advisory Committee for Aeronautics, the Office of Scientific Research and Development, and the Office of Production Research and Development of the War Production Board; it reports directly to Governor McNutt and acts on individual cases of scientific and professional personnel engaged in war research designed to develop or improve weapons of war.

At present the National Roster has advised the local Selective Service boards concerning approximately 15,000 individuals registered with the Roster. The Roster has also furnished special advice to the Office of the Adjutant General, War Department, concerning approximately 6,700 Roster registrants who have been inducted into the Army of the United States. The War Department has requested the Roster to provide this information so it can be considered in determining the best utilization to be made of the inductee in the armed forces. In total result, these procedures perform in the United States the same function which is performed in England by procedures which provide for the reservation of certain scientists for war work.

The Roster recognizes that probably the most important function of scientifically and technically trained men in the war is in direct service with the armed forces of the nation. It is clear that modern warfare requires for its successful accomplishment specialists who have the same sort of basic intellectual abilities that have made them the good peacetime chemists, biologists, and civil engineers. Thus, in thinking about the proper utilization of technically trained men in America, the Roster has emphasized over and over again that care must be exercised to avoid two common fallacies. The first is that professional men must not think that they can serve the country at war only in a civilian capacity. Second, they also must not believe that if called into the Army or Navy they must necessarily serve only in the field

for which they have been professionally trained. The Roster knows that the general needs of the armed services are such that men of high ability, particularly those with the sort of brains that have made them good students in science and mathematics, must be secured from the general population. Such good brains in young bodies must then be trained for a multitude of special jobs in the armed forces which require such ability but have no full counterpart in civil life.

While no final and absolute machinery for the allocation of professional workers to necessary wartime jobs has yet been developed, and, of course, no authority to make mandatory assignment has yet been granted, it can be anticipated that at least a process of more active allocation of individuals will now be developed in the professional fields contained in the List of Critical Occupations. The Professional Surveys Section's continuing factual estimates of personnel supply and demand, its survey of educational and training agencies, and the Roster's perpetual inventory of the location and qualifications of all such personnel will be of basic importance to any such program.

In the prosecution of modern warfare, it is obvious that victory will be achieved only by the adoption of appropriate measures to make proper contact between the right man and the right job, either in the combat services or out. The National Roster of Scientific and Specialized Personnel was conceived to meet this problem at the high professional and scientific levels.

After victory, in the period of demobilization and the development of a new peacetime economy in America, the Roster will still have an important national service to perform. In cataloguing the civilian skills of service personnel, both the Army and Navy have adopted a numerical system which is largely based upon the punch-card code developed by the National Roster in dealing with these same areas of specialization. The new skills gained by scientists in the Army and Navy may also be catalogued in connection with the previous peacetime abilities of the same individual. This new listing of the abilities of America's highly trained veterans can most effectively, therefore, be made part of the complete records of the Roster. The increasingly close relationship between the Roster and the local offices of the United States Employment Service, and between the Roster and the great industrial and educational employers of professional personnel will facilitate the effective utilization of its records and experience in making effective and factual the gigantic post-war placement of America's highly trained personnel.

# WHENCE THE HEAT OF SUN AND STARS?

By WILLIAM T. SKILLING

INVESTIGATIONS of the heat of the sun and stars begin at home, on the earth. The first step is to determine how much radiant energy is received by the earth from the sun. After making allowance for the part absorbed in the earth's atmosphere, scientists have found that a square centimeter at the surface of the earth and perpendicular to the sun's rays receives about two calories per minute. Changing from the units of science to those of everyday life, it is found that the earth receives energy from the sun at the rate of about one and one-half horsepower per square yard, or about 230 million million horse power on the whole earth. Even this incomprehensibly large total is only a small fraction of the energy the sun radiates, for the earth as seen from the sun would appear smaller than Venus does from the earth when it is an evening star. The sun actually radiates more energy in a second than the earth receives from it in sixty years.

## I

Ever since primitive man began to cook his food and warm his caves, fire has played an important and interesting role in human life. One can scarcely be surprised at the development of fire-worship among the ancient Persians and many other peoples. When prehistoric man began to try to discover the reasons for the things in his environment, fire and its accompanying heat must have been near the top of the list of his problems to be solved. Within historic times the ancient Greeks considered fire as one of the four "elements," as they called them, out of which the world was made—earth, air, fire, and water.

Early philosophers thought of heat as a sort of fluid substance, much as they looked upon electricity as composed of two fluids, positive and negative. Later they called the heat fluid "caloric" and thought it existed in all substances, flowing out when they were hot. Not until about the time of the Revolutionary War was this idea succeeded by the energy theory. Count Rumford was one day watching men boring a cannon and noticed that the amount of the heat of friction seemed to be in direct proportion to the amount of energy the men expended. When they put mechanical energy into the brass, heat came out of it. He and other contemporary scientists developed from this observational beginning the present theory of the equivalence of energy and heat, and measured the amount of each that is equal to the other.

There are many kinds of energy besides mechanical (used in the boring of cannon). There is chemical energy in the fuel that produces heat in burning; electrical energy that is changed to heat and light in the lamp filament; and subatomic energy that is changed slowly to heat in radioactive elements.

Chemical energy is liberated in the form of heat when two or more atoms unite to form a compound. Burning usually consists in the uniting of oxygen with either hydrogen or carbon. Sometimes the hydrogen and carbon of the fuel are already united with other elements or with each other, as in wood and petroleum oils. Coal and charcoal are mainly carbon. If the atoms of fuel are chemically joined into compounds, the compounds are first broken down by the heat and then their hydrogen and carbon unite with the oxygen of the air to form water vapor and carbon dioxide. It is in the forming of these compounds that heat is evolved. A gram of hydrogen, when burned, gives 34,000 calories of heat, and a gram of carbon only about 8,000 calories. This is why petroleum oils used as fuels give more heat than coal does, weight for weight.

## II

That fire or any sort of chemical action would be wholly inadequate as a source of the heat the sun radiates can be shown from the data given above. A sun made of coal mixed with enough oxygen to burn it could not have lasted even since the beginning of the Christian Era—about 1600 years would have been its limit with the present rate of radiation. When hydrogen unites chemically with oxygen (burns), it produces more heat than is produced by the burning of an equal

weight of any other fuel, but if the sun were composed of hydrogen, together with enough oxygen to make combustion complete, the heat generated by this best fuel would be less than the sun radiates in 2700 years. Another objection to the theory that hydrogen has been the sun's fuel is that all the 2700 years' supply of heat would have been generated in one instantaneous explosion!

The first explanation seriously considered by scientists as to a possible source of the sun's heat was offered by Helmholtz nearly a century ago. He explained that if the sun was once a great mass of gas extending out very far into space around its present position, the compression of the gases as they fell in toward the sun's center would produce heat. He computed on the basis of sound physical principles that in this way the sun could have been kept going for some 25 million years at its present rate of heat output.

By the early part of this century geologists had found evidence that the earth, and therefore the sun, are both much older than they had supposed, so much older that the Helmholtz contraction theory cannot account for enough heat. It has been at least 1500 million years since the earliest rocks of the earth began to form, and at least 500 million years since low forms of life began to exist on earth. During this long period the sun must have been giving out approximately the amount it radiates at present, for living organisms cannot exist and reproduce themselves far outside of the temperature range of from 60° below zero Fahrenheit to 140° above, a difference of only 200 degrees. Since the temperature of the sun, even in its exterior layers, is approximately 10,000°, a very slight percentage variation in its temperature would throw the temperature of the surface of the earth outside the limits within which life can exist.

Radioactivity, the very phenomenon that indicated most clearly the great age of the earth, seemed for a time to offer a suggestion as to a possible source of its heat. But further consideration showed that, although the elements that are radioactive, such as uranium and radium, do give off heat constantly and uranium would continue to do so for a sufficient length of time, the sun would need to be made entirely of it in order to account for the sun's rapid rate of radiation. The spectroscope shows, however, that the sun is composed of hydrogen, helium, calcium and many other lighter elements in great abundance. Consequently it is necessary to conclude that the continuing supply of the sun's heat is not derived from uranium or radium.

## III

At about the beginning of this century scientists began to explore the interior of the atom itself. They found it to consist of a nucleus around which revolve lighter particles which they named "electrons." The electrons of the atoms of all substances are alike, whether of hydrogen, carbon, iron, gold, or any other element, but the number of electrons and their distributions vary from the atoms of one element to those of another.

The nucleus is the most important part of the atom, for it can lose several or even all of its electrons (become ionized) and still be an atom of the same element. Presently, however, it will capture its normal number of electrons and return to its un-ionized state. But if the nucleus, the part that gives the atom nearly all of its weight, loses or gains something, it becomes a different element. It is the nucleus in *radioactive elements* that spontaneously, though slowly, breaks up, sometimes in successive steps. For example, out of uranium atoms there emerges, step by step, a series of lighter atoms—radium, lead, and helium.

The nucleus of an atom is composed of two kinds of particles—protons and neutrons. One proton forms the whole of the nucleus of a hydrogen atom. To say that a proton is the nucleus of a hydrogen atom is sufficient definition of it. It therefore weighs almost the same as an atom of hydrogen, for there is nothing else in an atom of hydrogen except one electron, and protons are about 1840 times as heavy as electrons.

The nuclei of other atoms are made up of several protons and about an equal number of particles called "neutrons," almost equal in weight (mass) to a proton, but neutral electrically; hence the name *neutron.* Protons are charged with positive electricity, and electrons have an equal charge of negative electricity. Normally there are as many elec-

trons as protons. This results in the atom as a whole being neutral except when it has lost one or more electrons.

Protons and neutrons are held together in the nucleus with a force that may be compared with that which holds atoms together in a chemical compound, but the force uniting the protons and neutrons in an atom is vastly greater than that uniting the atoms of a molecule. Therefore the nucleus is much harder to break up than a compound. Even the most strongly held compounds can be broken into atoms by sufficient heat, but it has not been possible to produce a temperature high enough to break up the nuclei of atoms. However, in the sun, deep down toward its center, where, according to Eddington's theory, the temperature must be near 40,000,000 degrees Fahrenheit, the energy of motion of the moving particles is sufficient to break up other particles which they strike. The speed of atoms at such temperatures is around 500 miles a second, a velocity at which their kinetic energy is sufficient to break apart protons and neutrons of several of the lighter atoms, permitting them to rearrange themselves in a different way, that is, to form different atoms.

Thus at the center of the sun, elements are changed into other elements, a thing that the ancient alchemists tried in vain to do, and that chemists could not do until the year 1919 when Lord Rutherford succeeded in changing a few atoms of nitrogen into atoms of oxygen. He and other scientists who have transformed atoms have used electrical and electromagnetic means of giving to the bombarding particles the necessary high velocities. In the laboratory, velocities many times as great as those caused by the high temperatures within the sun and stars can be produced, but the experimenter can work with only a small number of atoms, while in the sun practically all the particles have high enough velocity to give them high energies. In the cyclotron (the atom smashing machine of E. O. Lawrence) only one-tenth of a milligram of protons passes through the machine in a day's work.

## IV

H. A. Bethe, of Cornell University, has shown, by basing his argument on laboratory experiments and well-established theory, that the five elements—hydrogen, helium, carbon, nitrogen, and oxygen—are capable, under conditions existing in the sun, of furnishing all the heat the sun gives off. He explains an interesting series of atomic changes among these elements that are possible under the influence of the intense bombardment of one atom by another caused by the temperature of 40,000,000 degrees. He can calculate how much heat is liberated by these changes from one atom to another. The final result of the various steps in changing from one element to another is that hydrogen is gradually used up and helium is gradually produced. Four atoms of hydrogen are built up by an indirect process into one atom of helium, an atomic change that liberates immense quantities of heat. The net result of the change from hydrogen into helium is that 19,000,000 times as much heat is produced as would be liberated by burning an amount of coal equal in weight to the weight of the hydrogen used in the process.

The step-by-step changes, known as the carbon cycle, by which the hydrogen becomes transformed into helium are, briefly, as follows:

(1) The nucleus of a hydrogen atom collides with the nucleus of a carbon atom and becomes absorbed in it, changing it to the nucleus of an unusual form of nitrogen (an isotope). Written in symbols the action that takes place is shown thus:

$$C^{12} + H^{1} = N^{13} + \gamma.$$

The figures attached to the letters as exponents indicate the number of protons and neutrons in the atom, and therefore the approximate atomic weight. (Fourteen is the number of protons in the usual kind of nitrogen.) The Greek letter gamma means that a gamma ray (one of very short wavelength) is given off in the process.

(2) The $N^{13}$ nucleus produced by the above action is a short-lived radioactive element and quickly gives off an electron, which changes it into a carbon nucleus, the isotope C with only 13 protons and neutrons:

$$N^{13} = C^{13} + \varepsilon^{+}.$$

The Greek letter epsilon indicates an electron, and the plus sign shows that it is the very unusual variety of electron that is positively charged.

(3) This carbon atom, though not of the ordinary kind, is a stable element and lasts until it is hit by a hydrogen nucleus. Then it absorbs the H atom and becomes a nucleus of the ordinary nitrogen atom and gives off a second gamma ray, according to the formula:

$$C^{13} + H^1 = N^{14} + \gamma.$$

(4) This newly made atom of nitrogen is struck by another hydrogen nucleus which it at once absorbs to make an atom of an isotope of oxygen. The surplus energy is given off as another gamma ray with the following result:

$$N^{14} + H^1 = O^{15} + \gamma.$$

(5) The above isotope of oxygen $O^{15}$ is so unstable that it lasts but two minutes, on the average, when it gives off another positive electron and changes into an atom of nitrogen, the stable isotope $N^{15}$ as follows:

$$O^{15} = N^{15} + \varepsilon^+.$$

(6) Though stable this atom of nitrogen is broken up by being struck by another proton (hydrogen nucleus). This time the proton is not simply absorbed but the 15 parts, protons and neutrons, of the nitrogen nucleus, and the one proton of hydrogen fall together in the form of two nuclei, those of the ordinary carbon atom and of the helium atom:

$$N^{15} + H^1 = C^{12} + He^4.$$

This ends the series because helium is an atom so firmly held together that it successfully resists all the bombardment that is brought against it by the flying protons, even at a temperature of 40,000,000°.

The hydrogen that has taken part in this series of changes has disappeared as such, but has reappeared in the form of helium. Four atoms of hydrogen have united (indirectly) to form one atom of helium. The only other atoms which have taken any part have been carbon and the atoms of nitrogen and oxygen into which the carbon has been transformed during the changes. These atoms of nitrogen and oxygen change back into the original carbon atom at last, so that the final result is just as much carbon as at the beginning, and one new element, helium. The only thing destroyed is hydrogen, and the only thing made that lasted is helium.

The significant change that concerns us is that the helium made from the hydrogen *weighs less than the hydrogen did.* This difference in amount of matter that does not reappear in the form of an equal amount of some other kind of matter must still exist as *energy.*

Before we can know how much energy has been liberated in these changes we must know how much of a loss of matter there has been. The four atoms of hydrogen from which the one atom of helium was made weighed 4.03252 "mass units"; the helium resulting weighs only 4.00386. The difference, which is seven tenths of one percent of the original mass, shows how much matter has been changed into energy.

Science owes to Einstein the discovery of an equation expressing the relationship between matter and energy. It is a part of his theory of relativity. By substituting the value of the lost mass (weight) in the following equation the energy equal to the mass can be computed:

$$E = m \times c^2,$$

where E is energy (in ergs), m is the mass lost (in grams), and c is the velocity of light in centimeters per second ($3 \times 10^{10}$). Incidentally, the equation would be true even if mass in pounds or any other unit were used, and velocity in miles per second, but this would give energy in a different unit.

The net result of the carbon cycle is that four atoms of hydrogen, atomic weight 1.00813 each, are changed to one atom of helium, atomic weight 4.00386. Therefore, for every gram of hydrogen so changed there has been a loss in weight of 0.007165 gram of matter. This mass substituted in the energy-mass equation shows that (after ergs have been changed to calories) $15.4 \times 10^{10}$ calories have been produced. Only 1/140 of a gram of mass is lost in changing a gram of hydrogen into helium, and therefore only 1/140 as much energy is produced as would be produced if protons could destroy electrons, as formerly was thought probable.

## V

The number of calories of heat sent out from the sun can be computed from the known amount falling on the earth (nearly 2 calories a minute on each square centimeter of cross-section at right angles to its rays). The result comes out $9 \times 10^{25}$ calories per second as the total radiation from the sun. By

way of illustration, this is enough heat to melt a mass of ice equal in mass to the whole earth, to bring it to the boiling point, and to boil it all away in only thirteen and a quarter hours, provided only that all the heat could be concentrated upon the ice and be absorbed by it.

To furnish such a stupendous amount of heat as the sun radiates, a great deal of its own substance must be used up by converting it into energy. This loss in weight that the sun must suffer in order to furnish as much heat as it radiates is 4,700,000 tons every second.

It would appear at first thought that the sun would soon exhaust its resources and even that there should be nothing left of it, or at least of its supply of hydrogen, the part destroyed in the carbon cycle process. But the sun's mass is so tremendous (332,000 times that of the earth) and the heat equivalent of mass is so great that only one percent of the sun would be used up in producing heat for a billion years. From spectroscopic observations it appears that about one-third of the sun's mass is hydrogen, or enough to continue the carbon cycle and the radiation of the sun at its present rate for over 30 billion years more!

What has been said of the evolution of energy that maintains the sun's radiation can be applied equally to the stars, or at least to those that are most like the sun. There is a class of stars called red giants that are thought to be too cool at their centers to carry on the carbon cycle of changes. The source of their heat has not yet been explained, but stars belonging to what is called the "main sequence," although quite different in external temperatures, are supposed to be hot enough within so that the violent agitations of their atoms break up their nuclei, as in the sun, and provide the vast energies which they radiate.

# SCIENCE ON THE MARCH

## NEW LIGHT ON STELLAR SYSTEMS

Dr. Edwin Hubble, of the Mount Wilson Observatory, has announced a conclusion respecting exterior galaxies of stars that answers a question that has long been asked, and that lays the foundation for investigating the origin and evolution of these great stellar systems.

In the nineteenth century astronomers made enormous progress toward the solution of two problems that previously had been regarded as forever beyond the reach of science. They went far toward determining with the spectroscope the chemical composition of the sun; and they measured approximately the dimensions of the Milky Way system of stars. Our Milky Way system, or galaxy, is composed of possibly one hundred billions of stars, many of which are similar to the sun, some of which are much larger and brighter and some of which are smaller and fainter. In shape, it is disc-like with a diameter from rim to rim of approximately the distance light travels in one hundred thousand years and with a thickness about one-seventh as great. The dimensions of the galaxy are not very well defined because it has no definite surface.

As astonishing as were the facts about our galaxy when they were first established, they were only the prelude to the discovery of others incomparably more amazing. Astronomers had long noticed small, faint patches of light in the night sky that they assumed were drifting wisps of nebulous matter, stray fragments of world-stuff that were left behind in the formation of the stars. Near the close of the past century, James E. Keeler, of the Lick Observatory, found with a new photographic telescope that these fragments of primordial matter, as they were assumed to be, are very much more numerous than had been supposed. Presently many of them were observed to be spiral structures having fairly well defined central masses from which two arms coiled spirally outward. Their large numbers and peculiar structures aroused curiosity and stimulated astronomers to investigate them.

For twenty years the spiral nebulae, as they were called, were studied at the Mount Wilson, Lowell, and Lick observatories, and at other great observatories throughout the world, before their true nature began to be clearly understood. The idea that they are little clouds of nebulous matter, wandering among the stars, was so firmly fixed in the minds of astronomers that it was only with difficulty that they could come to realize that the spiral nebulae are not small masses in our galaxy, but systems similar to our own and far beyond its boundaries.

Once the earth was thought to be the major part of the physical universe, then it was the sun, and later our Milky Way System of stars. At each stage the limits of the imagination appeared to be reached. Only a generation ago this ultimate limit appeared to be our galaxy—a system of billions of solitary suns like our own, of uncounted numbers of doubles, triples and higher multiples, of great, loose swarms in flight together through the immensity of space, of dense globular systems consisting of hundreds of thousands of stars! Then the apparently little, faint nebulous wisps of primitive world-stuff, in a few years not long ago, were proved to be great galaxies, in a general way somewhat similar to our own.

How far away in space are the exterior galaxies and how many of them are known? There are only about a dozen so near that their light comes to us in less than a million years. The remainder are much more distant, existing telescopes and photographic plates being able to record the larger ones at a distance of at least one hundred million light-years. Within this vast neighborhood of our own stellar system there are probably as many as a million other galaxies.

Among the interesting questions that naturally arise is that of whether the galaxies are uniformly distributed through the space that has been explored. A few years ago Dr. Harlow Shapley, Director of the Harvard College Observatory, found unmistakable evidence that many of the known galaxies are grouped into clusters of galaxies, or supergalaxies, consisting of a dozen or two to more than a hundred galaxies. In fact,

our own galaxy appears to belong to a small group that may be part of a large, loose cloud of galaxies.

Galaxies are clearly dynamical systems. The spirals maintain their particular shapes because of the motions of their parts, just as the planets do not fall into the sun because of their orbital motions. The two arms of the spiral galaxies coiling outward from opposite sides of their nuclei should give a clue to what interior forces are in operation and what motions are taking place. Clearly under the laws of motion and the law of gravitation, matter cannot move along the arms of spirals, either inward or outward. Apparently the only reasonable conclusion is that the spirals are rotating in their plane, perhaps gradually contracting or expanding. The question of dynamical importance that promises to throw light ultimately on their origin and final end is whether they are rotating in the direction of the convex sides of their spiral arms so that they will be continually more and more tightly wound, or whether they are rotating in the opposite direction toward the concave sides of their arms so that they will gradually become unwound and be scattered in space.

It is easy to ask such a question, but very difficult to find the answer. Spiral galaxies are on such a vast scale and their interior motions are so slow that no perceptible change can be expected in their appearance in many thousands of years. But by ingenious, somewhat indirect methods V. M. Slipher, of the Lowell Observatory, a number of years ago inferred that spiral galaxies rotate in such a direction that their arms continually become more and more tightly coiled. This is the conclusion that Dr. Hubble has just substantiated by more conclusive evidence in the case of each of fifteen spirals with no exception.

What the consequences of this conclusion will be cannot be predicted at present. Whatever they may be, they will apply to our own Milky Way System of a hundred billion suns. In the light of what has been learned from exterior spiral galaxies, it has been found that the Milky Way System is itself a spiral, although from our location far in its interior we cannot determine in which direction its spiral arms coil. It has been found, however, that at our distance from its center the period of its rotation is of the order of one or two hundred million years. Astronomers are now face to face with the problem of determining the nature of its dynamical evolution during billions of years.

As always, after excursions afar we understand things better at home; as always, after shrinking before the vastness of the universe about us, we rise above our low-vaulted past.

F.R.M.

### DDT, A NEW INSECTICIDE

In the newspapers of January 2, 1944, there appeared an item on a new ingredient of a powder adopted by the Army as one means of protecting soldiers against the annoying attack of body lice and the diseases that may be transmitted by them. Only the background of this development can be given here; after the war the full story may be told.

The chemical control or poisoning of insect pests first attracted public attention after the Civil War, when it was shown that the potato bug (Colorado potato beetle) need not be picked off potato plants by farm children but could be more completely and easily controlled by dusting the plants with an arsenical pigment, called Paris green. To be sure, the beetle and their pink grubs or larvae would have to eat a little of the potato foliage in order to ingest the poison coating the leaves, but the leaf tissue so lost was insignificant compared with the total defoliation of plants that often occurred when the beetle was allowed to feed without hindrance. The successful application of Paris green led to a search for other arsenical compounds that would be just as effective for killing plant-eating insects, but less likely to burn tender foliage. So Paris green was largely superseded by lead arsenate for caterpillars and by calcium arsenate for beetles, compounds that are still important ammunition in our fight against insects. The latest and most promising arsenical insecticide is basic copper arsenate. During the 1930's inorganic fluorine compounds rose to a well established position among stomach insecticides (substances that kill only those insects capable of swallowing them with their food).

Now cryolite, a natural fluorine-containing mineral from Greenland, stands ready to fill any gaps in our defenses that may result from shortage of arsenical insecticides, and it has preferred uses also.

The insects that suck plant juices by inserting their beaks into plant tissues or those that similarly suck animal blood cannot be killed by covering the surface of the plant or animal with a stomach insecticide because the insecticide does not enter the fluid imbibed by the insects. Such insects may be killed by contact insecticides; that is, by substances toxic to the insects upon contact with the surface of their bodies. One of the first contact insecticides was an extract of tobacco, now used in the form of solutions of the active ingredient, nicotine or a salt of nicotine. Kerosene emulsions and lime-sulfur solutions become popular for scale insect control. In more recent years the ground flower heads of pyrethrum (a kind of daisy) and the ground roots of tropical woody plants called derris, cubé, or timbo, or extracts of them containing their active ingredients, have been employed as contact insecticides. They are highly desirable because, unlike inorganic insecticides, they are practically harmless to man, animals, and plants.

The rise of the latter plant insecticides in the 20's and 30's followed closely upon the successful work of organic chemists in isolating, identifying, and determining the structural formulae of their active ingredients. It was hoped that these toxic compounds could be synthesized commercially, thus making their production independent of foreign agricultural sources. Although that hope could not be realized, the chemical work done stimulated the synthetic preparation of both known and previously unknown organic compounds for laboratory testing as stomach and contact insecticides. Not only tax-supported laboratories but also the research laboratories of the great chemical industries set to work to synthesize compounds that might be useful as insecticides. Moreover, surveys were made of the insecticidal potentialities of organic compounds that had been prepared or were being manufactured for other purposes.

Although many of these synthetic organic compounds were found to be highly toxic to insects, most of them were discarded for various reasons: they injured plants or man and animals, they were too expensive, or they did not stand up under conditions of practical use.

At the present time entomologists cannot point to a single thoroughly successful synthetic organic stomach insecticide. But gradually it became apparent that stomach insecticides are not necessary for controlling all insects that bite off and swallow their food. In fact they, as well as sucking insects, may be killed by contact insecticides, not only by spraying or dusting the insects themselves, but by coating surfaces upon which the insects move and thereby killing them by crawling contact with the insecticide.

Fortunately the search for synthetic organic contact insecticides has been more productive than that for similar stomach insecticides. Certain organic compounds characterized by long straight chains of atoms linked to a sulfur, carbon, and nitrogen group (thiocyanates) have been and are widely used contact insecticides. Other compounds of different structure have given results of such promise that the hope of finding better compounds has never waned and the search goes on.

Before the United States entered the war our insecticide laboratories were well equipped to make and test promptly almost any organic compound. The work was going ahead so rapidly that it seemed that nothing of potential value could be overlooked. Yet in the fall of 1942 a Swiss company through its United States subsidiary called the attention of the United States Department of Agriculture to an organic contact insecticide that was said to have been used effectively in Switzerland. The chemists of the Bureau of Entomology and Plant Quarantine identified it as dichlorodiphenyltrichloroethane, which could be made from chlorobenzene and chloral hydrate (knockout drops). Later it was given the nickname DDT, the initial letters of parts of the long chemical name. This crystalline organic compound was sent to the testing laboratories of the Bureau and to the Crop Protection Institute. Astounding reports came back of its long-lasting effectiveness against

both insects affecting man and animals and those attacking crops. And it did not seem to hurt the plants or animals that were protected by it, nor man who used it! The Army wanted it in large quantities for louse powder. Consequently every manufacturer of insecticides quickly became aware of it and research on its potentialities is proceeding furiously in all quarters. That it will solve all problems of chemical control of insects is to be doubted, but it seems safe to say that an insecticide star has been born.

F.L.C.

### ANTIQUITY OF MAN IN AUSTRALIA

Interest in the problem of the antiquity of man in Australia has been stimulated by the finding of two fossil human skulls and other bones at a depth of nineteen feet in the side of a sand pit near the village of Keilor, ten miles northwest of Melbourne. One skull is practically complete, although its lower jaw is missing, while the other is represented by five fragments. A quartzite flake, evidently a crude implement, was found embedded close to the place where the intact skull was unearthed. Because of present wartime conditions it has not been possible to conduct systematic excavations at the site, in an effort to obtain additional bones, teeth, and artifacts, but studies have been made of the anatomical characteristics of the skull and of the geology of the location where it was found. From the skull comes evidence bearing on the nature of the early Australians, and from the geologic investigations an indication of the time when the individual and his companion were living there.

As is the case in the New World, there have not been many finds in Australia that could be considered indisputable evidence for early occupancy or that shed much light on the physical makeup of the people. A broad outline of developments in the area has been made, however, on the basis of the racial features of the later aborigines and the manifestations of such of the archeological and paleontological discoveries as appeared to be authentic.

When the first Europeans arrived, two types of people were present in the region. One was confined to the Australian mainland and the other to Tasmania. Both have been considered as representing the oldest types of the human race persisting into modern times. The Tasmanians became extinct in the latter part of the 19th century, although a few mixed-blood descendants are believed to survive in a few places. They differed from the Australians in appearance and in having a lower cultural level and generally are considered to have been a primitive Negroid people.

There are several schools of thought concerning the relationship between the Tasmanians and the Australians. One holds that both stemmed from the same basic stock and that such differences as were apparent were the result of isolation on the part of the Tasmanians and the fact that they developed certain variations peculiar to them during the long interval when they were separated from those inhabiting the mainland. Another viewpoint is that the aboriginal Australians were bi-racial in origin, that they were the result of a mixture of peoples related to the Dravidians, who came into the region as a part of the first wave of the great pre-Dravidian migration which spread from the Mediterranean across India into Ceylon and on to the Malayan region, and the Negroid peoples already occupying the continent. Both groups are believed to have journeyed from the Malay Peninsula to Sumatra, Java, and New Guinea, and thence into Australia. Others have argued that the Australians and Tasmanians were distinct and that the latter traveled to Tasmania by sea from New Caledonia, skirting the eastern shores of the continent. Consensus now tends to the theory of the early wave of Negroid peoples crossing into Australia from New Guinea and spreading thinly over the eastern part of the mainland. Later the incoming Australoids forced some of them south and west and into Tasmania, the crossing being made either by means of a then existant land bridge or by canoe over a much narrower strip of water than the present Bass Strait. Those remaining in Australia were absorbed by the newcomers, thus producing the intermixture responsible for the characteristic Australian aborigine. This bi-racial origin is, of course, regarded as being independent of and long antecedent to the admixture with Papuan and possible

Malayan migrants coming in from the north and northeast in recent times. The Australoids did not cross over to Tasmania until modern times and then only in small numbers.

Support for the bi-racial origin theory is believed to be offered by the Keilor skull which combines Australoid and Tasmanoid characteristics in about equal proportions. The cranium, which is that of a middle-aged male, is larger than the average for the males of several Oceanic races and in the form of its contour is considered as quite similar to the characteristic South Australian male. In many respects it may be regarded as representing an older form of the typical Australian, a feature which is consistent with the geological evidence indicating some antiquity.

Coupled with the twofold human migration to Australia is the interesting probability that the dingo, the dog that long was considered a distinct species peculiar to that continent but later demonstrated merely to be a variety of the domesticated dog, was introduced by the Australoids. The Tasmanoids had no dog and no traces of the dingo have been found in Tasmania.

One phase of the general problem naturally concerns the time when these events took place. The answer depends on the solution of additional problems in turn befraught with numerous difficulties. Inasmuch as some antiquity is indicated, Pleistocene phenomena are involved and in Australia there has as yet been no widespread correlation between glacial deposits, river terraces, sand dunes, alluvial deposits, raised beaches, and submerged strandlines. The order in which extinct marsupials died out is not known and some of those that have disappeared from the continent still survive in Tasmania. As a consequence such fossil remains give little aid in dating the deposits where they are found.

Several glacial phases of the Pleistocene have been established for Tasmania and Australia, however, and with them as a basis the investigators of the terrace where the Keilor skulls were found have reached the conclusion that it was formed during the Riss-Würm or Third Interglacial phase. Inasmuch as the bones occurred beneath undisturbed strata in the terrace and everything pointed to contemporaneity, Keilor man is judged to be of that age. The actual number of years involved is a question governed by the chronology used. On the basis of Milankovitch's Solar Radiation Curve it might have been as long as 143,000 years ago, while judged by some of the tables currently favored by European prehistorians the figure would be much more conservative and range from 40,000 to 50,000 years. Culturally the level would approximate that of the Lower Mousterian which, in view of the fact that in Europe that was the period of Neanderthal man, might appear to be a little too early. Having preceded the Australoids into the area, the Tasmanians would be somewhat earlier. How much older they were is still a matter for conjecture.

Other indications of relatively early occupancy are present in the form of stone artifacts occurring in deposits that obviously are of some antiquity. Perhaps the most important of these are the so-called Myrniong implements, crude scraping and chopping tools, found in a gravelly-clay underlying a volcanic lava flow. The stratum in which they were embedded has been identified as belonging to the Pleistocene, although the particular phase seems not to have been identified. At all events this evidence, together with that of the Keilor finds, suggests that it is reasonably certain that Australia was occupied by man during the Pleistocene period at a stage comparable to that of the Old Stone Age in Europe.

An interesting survey of this problem in which various finds are discussed and considerable attention is given to geologic and other ramifications of the subject has been prepared by Director D. J. Mahony of the National Museum of Victoria and it, together with articles on the anatomical features of the Keilor skull and the geology of the site where it was found, was published in the Memoirs of the National Museum, No. 13, at Melbourne in September, 1943. An extensive bibliography is included for the benefit of those desirous of delving into the subject more deeply.

FRANK H. H. ROBERTS, JR.

## CIRE PERDUE

WARTIME technology has revived and recreated for the production of the smaller tools of industrialized warfare, the ancient process of wax casting. This method, known as the *cire perdue*, or "lost wax process," is so called because the wax is "lost" in the process of heating, not because, as is mistakenly thought, it was a temporarily forgotten technique. It was the means by which were produced some of the world's greatest works of art dating back into historically remote ages. Three thousand years ago the Chinese were casting, presumably by this method, magnificent bronze vessels of such quality that even now, in this age of the machine and metallurgy, they are regarded as unsurpassed technical achievements.

Before the outbreak of this war the process was used in the field of art by the sculptor to cast his statuary and in industry by the jewelry and dental trades to manufacture small objects on a mass production basis.

With the war came a great need for machine parts and soon the facilities for hand forging and machining were seriously overtaxed. As a result, experiments were made with precision force casting as employed in making small jewelry and dental instruments. It was soon discovered that various methods of wax casting could not only relieve the serious situation by providing small precision parts but could also conserve critical raw materials, manpower, and production costs. After a year and a half, according to J. D. Wolf (*Metals and Alloys*, Oct., 1943), it is now "estimated that current production facilities within the jewelry industry alone, are adequate for the production of 100,000 small parts weekly on a subcontracting basis."

Briefly, the process involves the following. First a model is made in wax or plastic that can be melted or vaporized away. Then it is encased in moistened plaster, the plaster is dehydrated, and the wax is melted out in a furnace. This leaves a hollow in the hardened plaster, called an investment, which then is filled with metal through centrifugal, pressure, or vacuum methods devised to insure the flow of the molten metal into the extreme corners of the shape. The metal-filled mold is removed, cooled, and then the plaster is broken off or dissolved by water spray. The gate, which was the channel through which the metal was poured, is removed from the finished casting. Little or no tooling has been found necessary to remove irregularities. The larger the size the more difficult it is to obtain true dimensions by this method, but the most intricate small objects may be fashioned to an accuracy of a few thousandths of an inch.

Certain pitfalls must be carefully guarded against. Allowances are required for shrinkage, changes in shape and surface, and against occlusion of gas bubbles. The metal shrinks while cooling and in consequence the layout must be such that freezing shall first occur at the outer extremities of the pattern, and last at the gate in order that a surplus of molten metal may remain at the gate to the very end of the process and be sucked inward to replace the lost volume.

The disasters arising from a faulty technique are eloquently described by Benvenuto Cellini, 16th century master sculptor of Florence. Cellini, who gave a renascence to bronze sculpture by greatly developing the *cire perdue* method, had the heartbreaking experience, while casting his Perseus, of seeing the bronze "curdle" or solidify until, by dint of quick-sighted ingenuity, he caused the curdled mass to liquefy and "brought the dead to life again."

Wax casting is particularly suitable as a process for fashioning those non-ferrous metals and highly alloyed steels, many of which are extremely difficult to forge or machine, that are being used in the war for their strength and non-corrosive qualities. Examples of such small precision parts produced by this technique were recently displayed at the Washington headquarters of the War Production Board in an exhibition showing conservation of critical materials.

This wax casting method of part production as developed to meet the needs of industry at war may be regarded as having even greater potential use in the peaceful future, both in industry, where small parts can be produced for post-war machinery and gadgets, and in the arts, where there are no restrictions on size since millimeter accuracy is usually no concern of the artist.

M. D.

# BOOK REVIEWS

## INDUSTRIAL HYGIENE*

There is always room for improvement. There also is always need for improvement. In the leisurely days of peace and plenty the need is too often ignored or forgotten. It is in times of stress and emergency that great advances are made; the force of urgent necessity overcomes inertia and complacency. Our knowledge regarding industrial hygiene and industrial preventive medicine has far outstripped its application in many places. Though the larger corporations have splendidly organized the most effective industrial health services for their workers, the smaller plants have lagged far behind. Now these smaller plants, many thousand strong, are no longer small. Grown immense almost overnight, they have neither the trained personnel nor the experience to develop proper industrial hygiene services. The vastly accelerated tempo of wartime production makes their need for such services imperative.

There are not enough physicians and engineers trained in industrial health and safety problems to go around. Many formerly active in these fields are now in the armed forces. The many newcomers need to learn rapidly. For these and others newly concerned with industrial health, the Committee on Industrial Medicine, Division of Medical Sciences of the National Research Council, recommended that the Division of Industrial Hygiene of the National Institute of Health prepare a text briefly summarizing the accepted practices of industrial hygiene. This book is now available. It ably fills the need for a basic text for those trying to learn industrial health procedures.

Industrial production for war differs in several significant respects from production in peace. Speed and extreme accuracy are paramount. Thus the workers labor under sharper stresses and responsibilities. Anxieties and tensions beset us all and contribute to fatigue. Many new employees are untrained and green to factory practices. Workers are recruited from population groups heretofore unexposed to industrial employment; many women, youths, and handicapped persons are now for the first time members of production-line teams. Hundreds of thousands of older workers, discarded by industry years ago as "too old to work" are now back on the job and laboring mightily and effectively. With every man-hour of work vitally important in speeding production of military materiel, the conservation of the health, and therefore work efficiency, of each and every worker is essential to victory. All these factors sharpen the problems and augment the responsibility of those concerned with industrial health. It is no longer a question of saving compensation costs (unfortunately this was the original motivation of industry in creating industrial health services) but a problem of conserving the greatest of our national resources: *the work of men and women.*

A manual is not intended to be an exhaustively comprehensive work. But, as a result of careful and inspired editing, this manual of industrial hygiene is extraordinarily comprehensive. The delicate task of selecting material has been handled with rare skill by the editor, William M. Gafafer. The only major lack is the omission of a tabulation of health hazards in relation to occupation. The hazards from dusts, fumes, gases, irritating or toxic chemicals, and changes in the physical environment vary with the materials worked with and the processes involved. With the constant introduction of new materials and methods of processing, industrial health services must be constantly alert to *anticipate* such hazards. Lack of this knowledge is the greatest handicap encountered by the physician or engineer new to the field of industrial health. It is hoped that future editions of this valuable book will rectify this omission.

As in all books written by highly specialized contributors, there is some spottiness in the value of the various chapters. This, however, is less than one would expect when it is realized that the editor was obliged to choose his contributors from a very limited

* *Manual of Industrial Hygiene and Medical Service in War Industries.* Edited by William M. Gafafer. Illustrated. xi + 508 pp. 1943. $3.00. W. B. Saunders Company.

group. With one exception, all of the twenty-four chapters were written by members of the U. S. Public Health Service staffing the Division of Industrial Hygiene. Rare indeed is the organization which has within it the best men for each and every aspect of so huge a field.

The first part of the book deals with the problems of organization and operation of facilities for industrial health maintenance. Included are such aspects as medical, nursing, dental, and engineering services required. The second part briefly covers the more specific problems of prevention and control of disease in industry. Lastly are presented able discussions of the problems presented by handicapped workers and the vexing question of absenteeism. Most of the chapters are replete with useful information and ideas. Less ably presented are the chapters on health education and the complex problems introduced by the employment of women. Health education by those who must "read up" for their information is nearly always fatuous and too often misleading. The chapter on women in industry is reminiscent of a "library thesis"; extensive bibliographic documentation but too theoretical to be convincing.

Though there are many relatively recent books on industrial hygiene, this is by far the best brief compilation. It should be studied by all those concerned with the maintenance of health of the more than seven million workers on the war production front: executives, personnel directors, industrial physicians, nurses, hygienists, engineers, and even labor leaders. The printing and format are up to the high standards of excellency usual with the publishers. The volume is strong in the essential attributes of a manual; it is sound, concise, and selectively comprehensive. Its wide circulation is sure to improve industrial health practices where improvement is needed most—in the smaller plants. We may hope that the advances made in war will not be lost with the coming of peace.

EDWARD J. STIEGLITZ

## FOGS, CLOUDS AND AVIATION*

THE principal feature of Dr. Humphrey's conveniently small book on *Fogs, Clouds and Aviation* is the inclusion of ninety-three halftone plates of cloud formations and allied atmospheric phenomena. Many of these photographs were obtained by the author himself. Their value is enhanced by the very clear descriptive matter that not only differentiates one cloud formation from another by appearance, but explains the conditions under which the various cloud formations may take place.

The book is based on the author's earlier volume, *Fogs and Clouds,* which has been revised and brought up to date with the added emphasis brought about by the rapid advances in aviation since the earlier volume was published. Whatever Dr. Humphreys writes will be found not only authoritative but entertainingly written even to the extent of a dash here and there of poetic imagination.

The book supplements the usually somewhat inadequate treatment of clouds and fogs found in the more conventional textbooks of meteorology. It should prove of value not only to the aviator who must be constantly prepared to recognize the significance of cloud banks and conditions to be encountered therein, but also to an ever enlarging group of general readers whose amateur interest in phenomena of the weather finds an added satisfaction in being able to classify the ever varying cloud formations of the lower atmosphere. For the less-initiated, the inclusion of the rarer phenomena such as rainbows, coronas, and parhelic circles adds considerable interest to a book that is a welcome companion to all who would be weather-wise.

HARLAN T. STETSON

* *Fogs, Clouds and Aviation.* W. J. Humphreys. Illustrated. xii + 200 pp. 1943. $3.00. Williams and Wilkins Company.

## ESSAYS IN BIOLOGY*

YOU know what this sort of book is likely to be—a potpourri of noncoherent articles written for the occasion from whatever materials chance to be on hand. So I picked up my review copy some weeks ago with little enthusiasm. It is a good-looking book, well printed and bound and with many fine figures, especially the frontispiece portrait of Herbert Evans, Professor of Biology, Uni-

* *Essays in Biology in Honor of Herbert M. Evans.* By his friends. Illustrated. xxi + 686 pp. 1943. $10.00. University of California Press.

versity of California, whose sixtieth birthday was the occasion for its preparation. And it has the éclat of a collector's item, beginning with a biography and full bibliography of Dr. Evans, and continuing with each of the forty-eight contributions set off by an attractive fly-leaf. But the contents seemed to confirm my worst fears, for the first five articles, in order, deal with: the kidney and hypertension, endocrines and gut absorption, the impact of iron on religious thought, adrenalectomy and salt, Purkinje on the bird's egg.

Yet I read from cover to cover, with continuing profit and pleasure. The chaos in subject matter is not so great as at first seems; had the Publication Committee chosen to place the contributions by content, rather than alphabetically by authors, there would have been, perhaps, the following groups: endocrines, nearly half the articles, and two thirds of these dealing with reproduction and its hormones; scientific history, nearly a fourth of the articles; and another baker's dozen that are really miscellaneous. Perhaps the alphabetical arrangement is preferable, at that; it is a rather salutary mental shock to pass, over one page, from a description of the Symballophone, a double stethoscope, to an analysis of Carnot's thermodynamic theorems, or from the pathogenesis of undulant fever to the influence of the French Revolution on medical education.

Some few articles have obviously been tossed off as casual chores; others, such as the meticulous translation by Barthemez of Purkinje's tract on the bird's egg, are labors of love; and a few are simple, detailed reports of a research job. The majority are succinct and authoritative sketches of the recent work in and the current status of the field chosen. They are less formal and more personal than straightforward review articles and are correspondingly easier reading. For the biologist who enjoys brief excursions to far points in his domain and is willing to put himself in the hands of whichever guide is available, these "little journeys" will be most rewarding. A word as to how these guides were chosen, beyond the general fact of friendship with Dr. Evans, would have been welcome.

The Publication Committee—Miriam E. Simpson, Samuel T. Farquhar, Chauncey D. Leake, and William R. Lyons—has performed a generous and worthy service, and Herbert M. Evans is indeed honored.

R. W. Gerard

## A TREASURY OF SCIENCE*

Compilations of scientific writing have appeared before but none as readable as this one. The present collection has several unique and valuable features. It follows a logical and well planned course beginning with some fascinating excerpts on the poetry and excitement of scientific wonder which act as an inspiring foreword to the harder tasks of presenting results of actual scientific inquiry. Subsequent chapters deal with the heavens, the earth and matter, and energy. These chapters form the background for the sections on "Life" which are followed by chapters on "Man," his civilization, his physical structure, his mastery over disease, and his fragmentary insights into the workings of his own mind.

The compilers of this volume believe apparently that it is far better to present to the public scientific literature written by qualified authors who are good writers than by scientists who are competent or original research workers. It may well be claimed that there is no compilation of excerpts from original scientific sources that can compare with this achievement in painting the panorama of science in such clear colors as to compose a well balanced entity which is informative, readable, and enjoyable.

It must not be gathered that excerpts are lacking from original investigators. Such men as Isaac Newton, Charles Darwin, Sir James Jeans, Forest Ray Moulton, Sir Arthur Eddington, Benjamin Franklin, Galileo, and others are well represented by impressive quotations. But the vast majority of the pages of this collection is filled with articles from writers on science whose unique contribution is lucid exposition and organization of scientific findings.

It goes without saying that the personal equation of the editor enters into the matter of choosing particular selections, and that

* *A Treasury of Science.* Edited with an Introduction by Harlow Shapley with Samuel Rapport and Helen Wright. xi + 716 pp. $3.95. Harper & Bros.

different compilers would display different preferences. This is as it should be; it proves as helpful in science as it is in literature. But it is for this reason that those who are interested in the diffusion of scientific information should seek to find the possible causes for the intrinsic merit of this volume, as well as its rapid acceptance by the public.

An outstanding feature of this collection is its stress upon natural history rather than experimental methods and procedures. Physiology and biochemistry are brought in very mildly, if at all, and such topics as respiration, enzymes, vitamins, or digestion are virtually omitted—perhaps for the sake of easier reading.

One also notes the absence of science history. It might with justice be claimed that in portraying the drama of scientific conquests much stands to be gained from examples of false leads such as Tycho Brahe's defense of astrology, or Paracelsus' search for the spirit of digestion, or Priestley's adherence to the phlogiston theory. A reader might enjoy knowing that science has its deceptive leads as well as those that prove workable. However, the general trend of scientific writing to date is to omit this historical process and it is likely that its inclusion would confuse the reader.

It is difficult, however, to explain the absence of any cultural anthropology in the section on man, especially since ample space is given to biological evolution and physical anthropology. Surely the writings of Boas, Lowie, Linton, or a host of others cast valuable light on man and his nature and in addition constitute fascinating reading. The public, not only the scientists of today, is no doubt anxious to learn how man fashions and changes his institutions, the faiths he lives by, and how science can help to evaluate them.

On the other hand, Dr. Shapley's volume is so harmonious and effective and so expressive of the attitude of the editor that any changes might upset its homogeneity. As in a work of art this book owes its charm and value to the unique philosophical and literary conceptions of its compilers. As the reader continues with the wealth and variety of material presented, the many-sided edifice of science grows before him in strength and beauty. If my guess is correct, few readers will fail to finish it and all will be amply rewarded for having succumbed to its lure.

MARK GRAUBARD

# COMMENTS AND CRITICISMS

### Call to Arms

I believe that *The Scientific Monthly* ought to have a section dedicated to criticism of the writings it publishes. This would enhance its scientific spirit. —J. M. Martinez.

### Levitation

I am not accustomed to the general practice of making an issue of the presentations of scientists in Scientific Journals. An article in the *Monthly* for October, 1943, does, however, need refutation from many sources and I hereby contribute my objections.

This article by one Leo Kartman is mistitled, "Sociological Excursions of Biologists." It should bear some such caption as, "Biological Misconceptions of a Sociologist." . . .

The gist of Mr. Kartman's arguments on the theme of the non-applicability of biological laws to man is the hoary sociological thesis that man is a creature apart from this mundane world and not subject to the operation of forces that govern in the respective organic and inorganic spheres of influence.

I do not attempt to answer Mr. Kartman's naive presentations,—any "B" student who has completed a High School biology course could do that. I only ask that when such articles are in the future presented for your consideration, you accept them only on the condition that the author jump out of your window (I hope you are on the sixth floor) as a demonstration that the laws of gravity will be suspended in his favor because he is a human being.—R. A. Hefner.

No! We are on the eighth floor.—Eds.

### We Muffed It

On page 476 of the November, 1943, issue of *The Scientific Monthly* there is an attractive photograph captioned "Habitat Group of Quetzal from Guatemala." It is to be hoped that the Field Museum, to which this group is ascribed, has labelled it otherwise inasmuch as the alleged Quetzal birds in this illustration bear an extraordinary resemblance to peacocks but, on the other hand, do not resemble any illustrations of the Quetzal which I have seen. Nor do they resemble the recollection of the Quetzal on the part of travelers to Guatemala with whom I am acquainted.

It is suggested that the next issue of *The Scientific Monthly* contain an appropriate correction and, in accordance with the good-neighbor policy to our fellow American country, Guatemala (whose national emblem is the Quetzal), a new illustration, as well, showing the actual habitat group of the Guatemalan Quetzal.—Alfred N. Goldsmith.

Inadvertently the Field Museum sent us a photograph of peacocks mislabeled quetzals. We published it innocently. Later we obtained from the same museum a photograph of a habitat group of genuine quetzals. We intended to publish it, but the WPB intervened, requiring conservation of paper. Nevertheless our apologies to our Guatemalan neighbors are just as profound as if we had illustrated this acknowledgement and correction of our error. We also publicly express our appreciation of the restrained and delicate manner in which Dr. Goldsmith exposed our ignorance. After all we *have* seen peacocks.—Eds.

### Also Muffed

I suppose a million people have written to you that the life span of Louis Agassiz is not that indicated below his portrait in the last [October, 1943] number of *The Scientific Monthly*. I think that the dates relate to his son Alexander.—W. H. Wright.

They do, and we can't laugh *that* off.—Eds.

### No Ham and Eggs

I happen to be one of your members and receive *The Scientific Monthly* and I want to express some comments about the first article in the July 1943 issue entitled "The Older Worker." I wish that everybody in the country could read this article—read it with care and read it with thoughtfulness. It is excellent and I think Dr. Carlson has done a fine job in getting up this article and you have done a fine job in publishing it. . . .

I would also especially comment on page 6, column 2, commencing "In fact, tasks for which men and women past fifty, sixty and seventy are thoroughly capable lie all around us like mountains but we do not see them." This is so true with a great many but some of us, including myself, not only see the mountains but see the tasks as well. We are perfectly willing to pay a reasonable price for such work to be done and the different jobs are consistently coming to light and could be done by anyone—that is, as far as age is concerned—but we will not pay $12 a day for simple little tasks which a man seventy could perform even though it took him twice as long as a man of thirty. I, myself, would very willingly pay $5 a day but I certainly will not pay $12.00. These tasks are with us, they are all around us all the time, but the moment you suggest anything like $5 you are constantly up against this is below the union scale. The result is the work is undone, the older people are without the funds and no one accomplishes anything with this kind of an attitude.—W.H.H.

A copy of the foregoing letter was sent to Dr. Carlson by F. R. Moulton, whose letter of transmittal included the following:

You will remember that nearly twenty years ago, I wrote an article for The University of Chicago Magazine on ''The New Education'' and, in the course of it, spoofed the faculty on various things. One of the unorthodox positions I took was that younger scientists should be promoted rapidly so that they could get married and raise families at the normal period of life for doing such things, and that they gradually be demoted and retired as they got past the zenith of their powers. This proposal did not meet a very hearty response among members of the faculty who were past middle age. Now I hope that, from the vantage point of more years, you will see that there was some sense in what I said. If men could begin to be demoted at 55 or 60 or 65, depending upon their physiological ages, they could be kept actively at work in the universities for a much longer period, with advantage to research, education and themselves. Financially speaking, my suggestion amounts to distributing the total income of a man in university work somewhat differently than it has been distributed heretofore. Of course, there are those that thought there would be some humiliation in being demoted, at least as far as pay is concerned. If everyone were treated similarly, the demotion depending on physiological age, it would be normal, just as ceasing to play tennis at advanced years is normal, the time for this, also, depending to a considerable extent upon the physiological age.

If you agree with any of these wanderings of a restless mind, I hope sometime you will write an article, modifying them as you desire, and let us print it in *The Scientific Monthly*. It would be a fine, practical carrying out of the principles you set forth generally and rather briefly in the article which we have just printed. How about taking your facile pen in hand and doing this little trick, or if you disagree with me, take the opposite position, and fasten my hide to the barn door?—F.R.M.

### Ah!

Reading the book reviews in the November issue of *The Scientific Monthly* which has just arrived has brought once again to my mind the realization of how good they are. They are informative, critical, well balanced and good tempered. But the quality I like best is the note of frankness and sincerity: if the reviewer thinks the book is bad he says so. In too many of our professional journals, it seems to me, a reviewer says nice things about a book for which he has contempt for fear of hurting his ''colleague's'' feelings.

More power to your reviewers!—Leslie A. White.

### Oh!

I am in receipt of your letter, together with the return of my manuscript. I will wager that neither one of you three wise men realize the fact that degenerative processes are developing, which means a decay of our civilization. You pretend to publish a scientific journal, yet you have not the ''guts'' to publish the truth, and you probably have never seen nor heard of Antoine Wiertz's paintings.—H. W. Soper.

### The Professor

The following reflections come from Byrne J. Horton, Graduate Faculty, St. John's University. Contemplating the characteristics of the professions of law, medicine, theology, and advanced teaching, Dr. Horton advances ten criteria or earmarks of a genuine profession.—Eds.

1. A profession must satisfy an indispensable social need and be based upon well-established and socially accepted scientific principles.
2. It must demand an adequate pre-professional and cultural training. (Today, a two-year college course is generally required.)
3. It must demand the possession of a body of specialized and systematized knowledge.
4. It must give evidence of needed skills which the general public does not possess; that is, skills which are partly native and partly acquired.
5. It must have developed a scientific technique which is the result of tested experience.
6. It must require the exercise of discretion and judgment as to the time and manner of the performance of duty. This is in contrast to the kind of work which is subject to immediate direction and supervision.
7. It must be a type of beneficial work, the result of which is not subject to standardization in terms of unit performance or time element.
8. It must have a group consciousness designed to extend scientific knowledge in technical language.
9. It must have sufficient self-impelling power to retain its members throughout life. It must not be used as a mere stepping-stone to other occupations.
10. It must recognize its obligations to society by insisting that its members live up to an established and accepted code of ethics.

comes to qualities of the mind and the even less tangible personality, the standards are less definite and the methods of applying them less certain. However, Carlson certainly has a very wide range of interests and information and a ready and acute mind In the rough and tumble of banter and jibes which were common among the members of the faculty in the youthful days of The University of Chicago, he was well able to take care of himself. In faculty discussions he was objective and clear, never taking the role of either an obstructionist or a servile supporter of the administration Although his primary interests were in research, he gave serious attention to questions of sound educational policies. For example, he exerted an important influence on the development of the general survey course in science for freshmen at The University of Chicago, and not only contributed a chapter to *The Nature of the World and Man* to which it led but critically examined the manuscripts of all other contributors. From this lower level of college education Carlson's academic interests ranged to the other extreme of university administration

But such a bare catalog of what a man has done is only the skeleton of his life It lacks almost entirely the qualities of mind and heart that after all are the man. Probably the best brief characterization of the real Carlson is that he is a man of very rare intellectual integrity. Like Nature itself he never compromises with fundamental principles for an apparent advantage in the special case If in the exceptional case this quality seems severe, it is nevertheless the very property of Nature that makes science possible, and even life itself. And it is a necessary quality for human beings in order that a stable society may evolve.

In these days our thoughts inevitably turn to the future of society It is difficult not to be disturbed by the trials of the hour and the uncertainties ahead, but science is in the ascendency, at present in the production of means of destruction but soon in the more important task of teaching the integrities of life There will be ready hands to hold its flaming torch aloft, of which the president of the Association naturally will be the foremost leader For nearly seventy years he has been unknowingly preparing for this task—on a farm in Sweden, in many journeys across the oceans to many lands, in the discipline of manual labor, in the arduous processes of getting an education, in climbing the ladder of fame, in reflecting on the thoughts of wise men of the past, in learning the essential character of the orderly ways of Nature, and in distilling wisdom from the multitude of experiences that the varied currents of life have swept within his reach. May the Association prove worthy of his leadership!

F. R. M.

ANTON JULIUS CARLSON

birth is purely legalistic, because so far as American and Canadian scientists are concerned there is not and never has been any international boundary between them.

In 1925, Michael I. Pupin, once a Hungarian peasant boy but then the foremost electrical engineer in America, was elected president of the Association. A few years before his death Pupin wrote his autobiography, a book as remarkable for its rare literary and poetic qualities and his fine tribute to his mother as for the heroic story of his rise from poverty and ignorance, in a strange land, to great rewards and high honors from his adopted country.

Franz Boas, who was born in Minden, Germany, in 1858 and came to the United States in 1889, became president of the American Association for the Advancement of Science in 1931. At Clark University, in the department of anthropology of the Columbian Exposition in 1893, in the American Museum of Natural History, and as professor of anthropology in Columbia University, Boas maintained the pattern of fine and objective German scholarship as it was at the zenith of its excellence. It is the memory of such men as Boas that reminds us of the great debt American science owes to the spirit of German science of a few decades ago, and makes us grateful to Fate that he came to us when he did.

Anton J. Carlson is the fourth foreign born president of the Association since 1922, an average of one out of six at a time when this country had already become populous, powerful, wealthy, and sophisticated in science. This remarkable recognition of foreign born scientists of distinction is clear evidence that during this period the hospitable spirit of our ancestors still prevailed in this land, and conclusive proof of the high quality of many of those who were coming to our shores. When so many men in so few years receive such signal recognition of eminence where the possibilities of this particular recognition are so limited, it may justly be maintained that this has still been the land of opportunity of which ambitious and daring young men have always dreamed.

Carlson was born, in 1875, in a rural district of southern Sweden, yet at a latitude of 58°, or nearly as far north as the southern tip of Greenland. As a child in the country he shuddered at the roar of storms in winter, rejoiced at the rush of young spring, hardened his muscles and disciplined his mind with toil during the long days of summer, became acquainted with domestic animals, the life of lakes and streams, fields and forests, and the air, and looked forward to the snows of autumn. At sixteen years of age he turned his eyes westward and crossed an ocean and half a continent on his way to Chicago. Knowing hardly a word of English, he secured a job at carpenter work, saved the money he earned, attended school in the evening, and started in earnest on the adventures of life. After he had earned four hundred dollars he went to Augustana College, Illinois, at which he took the B.S. degree in 1898 and the M.A. degree in 1899. Whenever any graduate of one of the great universities looks with feelings of pity on such poorly endowed and equipped colleges as Augustana, let him think of the men they have produced and be humble.

In 1902 Carlson received the Ph.D. degree from Stanford University, at which he was an assistant in physiology during 1901 and 1902. After one year as a research assistant in the Carnegie Institution of Washington, he went, in 1904, to The University of Chicago where he rapidly rose in rank to the chairmanship of the Department of Physiology, and in 1929 was awarded the Frank P. Hixson Distinguished Service Professorship. The one break in this career was the period of his service in the United States Army Sanitary Corps in World War I. As a Lieutenant Colonel he was sent to Serbia, Austria, Czechoslovakia, the Baltic Provinces, and Finland after the armistice to direct American relief of the appalling starvation that existed in those countries.

What sort of man was and is Carlson? Such questions are always asked. The answers are almost as varied as those giving them. The writer of this sketch knew Carlson, at least slightly, almost from the time he entered The University of Chicago, and later very well. Physically he is slightly above the average in size, well muscled and always in excellent physical condition. He played tennis, billiards, and bridge. So much is easy and relatively certain. But when it

# ANTON JULIUS CARLSON

ON January 1, 1944, Dr. Isaiah Bowman, President of the American Association for the Advancement of Science for 1943, announced over the network of the National Broadcasting Company that Dr. Anton Julius Carlson, Frank P. Hixson Distinguished Service Professor Emeritus of Physiology in the University of Chicago, had just been elected President of the Association for 1944.

Dr. Carlson is the ninety-second president of the Association, his predecessors having included many of the most eminent of American scientists for a century. For example, three of the five American Nobel laureates in physics, A. A. Michelson, Robert A. Millikan, and Arthur H. Compton, have been presidents of the Association. Of the three American Nobel laureates in chemistry, Theodore W. Richards and Irving Langmuir were similarly honored. Of the six American Nobel laureates in medicine, four were American born, and of these four, Charles S. Minot and Thomas H. Morgan were also presidents of the Association.

In certain respects the National Academy of Sciences is the foremost American scientific society. It was established in 1863 by an Act of Congress as the official adviser of the Federal Government on scientific questions. Naturally only scientists of the highest distinction have been elected to the presidency of the Academy. Of the fourteen men who have been elected to this high office, eleven have also been presidents of the Association. Dr. Carlson is one of 335 present members of the Academy, having been honored by election to membership in this august body twenty-four years ago, in 1920.

Since the fields of interest of the Association include practically all the natural and social sciences, not many presidents have been elected from any one field. Dr. Carlson is the eighth president of the Association from the field of the medical sciences. Of the ninety-two presidents of the Association, seven have been mathematicians, nine physicists, ten chemists, ten astronomers, nineteen geologists, geographers, and paleontologists (eleven in the first thirty-five years), ten zoologists, seven botanists, five anthropologists, two psychologists, two economists, one engineer, eight medical scientists, one agriculturist, and one educator, the late President Eliot of Harvard University. Of course, the diversity of interests of former presidents has nothing to do with Dr. Carlson except to indicate the type of man that is chosen to be the leader of such a great body of scientists as those which make up the American Association for the Advancement of Science. In addition to being an eminent specialist, the president must be a man having many and varied interests, wide acquaintance, a deep feeling of responsibility of scientists to our social order, and a statesman in the fields of science. The election of Dr. Carlson as president of the Association expresses the judgment of the 255 members of the Council, representing the Association and societies in every field of science with a membership of nearly a million, that he has these high qualities to an exceptional degree.

Dr. Carlson is the fifth foreign born president of the American Association for the Advancement of Science, excepting J. E. Hilgard, president in 1875, who was brought from Bavaria to America by his parents when he was a young boy. Carlson's four predecessors who were of foreign birth and rearing made such great contributions to the development of American science that their names should be recorded in this sketch. The first in order of election was Louis Agassiz, of Swiss birth and Swiss and German education, who was elected president of the Association in 1851, three years after it was organized. He founded the Museum of Comparative Zoology at Harvard College, introduced revolutionary methods of teaching biology, and established the summer school at Penikese Island, which was described in the October, 1943, issue of *The Scientific Monthly*.

Seventy-one years elapsed before another scientist of foreign birth was elected president of the Association. In 1922, J. Playfair McMurrich of Toronto and of Canadian birth became president of the Association. But to speak of McMurrich as of foreign

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## HELIOS AND PROMETHEUS: A PHILOSOPHY OF AGRICULTURE


By PEI-SUNG TANG


LIFE denotes activity, and activity incurs the expenditure of energy. In man, the energy for his activities is derived from the consumption of food which is manufactured for him directly or indirectly by the green plant. When primitive man lives in the forest, supported by the fruits of its vegetation and deriving warmth from firewood, he is, figuratively speaking, a parasite. When gradually he learns the usefulness of certain kinds of plants and animals for food and fuel and singles them out for cultivation, propagation, and protection, he initiates the art of agriculture, emerging, we may say, from the state of parasitism to that of symbiosis.

While man and animals derive their food and fuel from the green plant, the latter is not the ultimate source of energy. It in turn obtains its energy from the sun through a unique process known as photosynthesis. This process, whereby the radiant energy of the sun is converted into chemical energy available to plant, animal, and man alike, is the fundamental reaction on which the existence of all higher forms of life depends, and on which is built man's art of agriculture. All the efforts of the practical farmer and of the agricultural scientist are directed, whether consciously or unconsciously, toward increasing the efficiency of certain green plants in the performance of this all-important function, directly or indirectly.

How is the sun's energy transformed through the plant into forms available to man? The green plant, with its characteristic pigments, converts carbon dioxide and water into sugar and other forms of organic material, thereby trapping, so to speak, radiant energy and changing it into chemical energy in food and fuel which, when consumed by man, supply him with energy for his activities. The process is at once simple and complicated. It is simple because water, sugar, and carbon dioxide are common stuffs of nature. That it is complicated we may infer from the fact that, in spite of all the efforts of the biologists and chemists, we are still ignorant of the mechanism of this process, let alone the ability to duplicate and control it in the laboratory.

Important as are such agricultural processes as the improvement of crops, animals, soils, or silviculture, and the prevention of diseases, they are merely means of improving a process on which man is dependent, but which he is unable to duplicate and control at his will. In the cosmic cycle of energy transformation, the green plant can very well be independent of man, but man cannot be independent of the green plant. The fundamental problem of human food production, from the biological point of view, is that of duplicating the process of photosynthesis in the laboratory, independent of the living plant. When that time comes, man will be freed from the grueling labors of agriculture and the cruel uncertainties of the elements. Before that stage of scientific development is reached, however, man will still have to rely on the green plant as the transformer of solar energy into forms available to himself. He is not only constantly subjected to the Malthusian struggle between himself and his fellow men; he is also involved in a four-sided competition for land area among the plant, the animal, the machine, and himself.

### Plant and Man

Civilized man, although he has long abandoned his worship of the fire and the sun, is not much further advanced than his ancestors; he is still shrouded in the mysteries of the fundamental relation between the sun, the green plant, and himself. Until the time when he can reproduce this apparently simple process of photosynthesis in his laboratory, independently of the green plant, man cannot claim to be free from the vestiges of his ancestral sun and fire worship. When that day comes, the energy awaiting his disposal will be enormous.

The tremendous amount of radiant energy falling on the earth's surface is hard for us to conceive. It is estimated that one square meter of the earth's surface receives from the sun the equivalent of about one horsepower, and the total radiant energy intercepted by some 200 million square miles of earth's surface is, at this rate, equivalent to 200 trillion tons of anthracite coal per year, which is 200,000 times our annual coal consumption. This amount of energy is equivalent to the total food requirement, in terms of heat value, of the entire world population for one million years! Or, putting it in another way, the radiant energy received on one thousand square miles of land in a growing season of 90 days, if all converted into food, would be sufficient for the heat energy required for the existence of the entire population of the world for one year.

Of this enormous amount of energy falling on the surface of the earth, how much is actually made available for human consumption by the green plant? When the entire plant is considered, not limiting ourselves to the portions used for food by man, only 0.5 percent of the solar energy falling on the sunflower plant is stored in the organic matter. For wheat, rye, and potatoes the figure is 3 percent; for corn it is 2 percent. In the case of forest trees, calculations show that for the redwood of California the efficiency is only 0.3 percent, and for the Eucalyptus tree it is around 0.5 percent. When only the edible portions of the crop plants are considered, the energy yield per acre, as calculated from records taken both in China and in the United States, are as follows: Indian corn, 2.6 million calories; wheat and barley, 1.6; field peas, 1.2; rice, 3.6; and Irish potatoes, 3.0. When compared to the solar energy received on one acre of land during a growing season of 90 days, which amounts to approximately 2 billion calories, these figures are only of the order of thousandths parts of the total radiant energy intercepted on the land surface during a growing season. And all the labors of the farmer, all the efforts of the agriculturalists, are directed only toward increasing the efficiency of certain plants in the utilization of these thousandths parts of energy of the sun intercepted by the earth!

The practice of agriculture, whereby the sun's energy is stored in food and fuel through the cultivation of green plants, is a very wasteful process of utilizing solar energy from the standpoint of cosmic relations between man, the green plant, and the sun. However, from the anthropocentric standpoint, this practice, wasteful as it is, is still a profitable proposition. Man, in the cultivation of his land, is only building a dam, so to speak, to guide a very minute portion of the otherwise untamed torrent of ever degrading energy from the sun into channels for the performance of useful work, much as a minor part of the wasted energies of the Niagara Falls is used for the production of electricity. Regardless of man's existence, the sun forever emits radiant energy in its process of degradation, and man's part is only in the capturing of an insignificant fraction of this degrading energy into useful work. The amount of labor expended in building and caring for the dam is the labor which man puts in for the cultivation and protection of the crop plants and farm animals, which is relatively small compared to the energy gained from his efforts.

For the cultivation of an acre of corn, 23 man-days are required in China as against 2.5 man-days in the United States. For the cultivation of winter wheat, the respective figures are 26 and 1.2, and for the cultivation of an acre of rice, 82 man-days are required in China. Assuming an average of 3,500 calories per day per capita for the food consumption of the farmer, the energy expenditures are: for corn, 80,000 for the Chinese and 8,800 for the American. For winter wheat, they are: 91,000 for the Chinese and

4,200 for the American. For the cultivation of an acre of rice, the Chinese farmer puts in an amount of labor equivalent to 290,000 calories. For these amounts of energy put in, an average yield of 2 million calories per acre is realized, resulting in the apparent gain of energy from 7 to 25 times for the Chinese, and from 200 to 500 times for the American.

The low energy input for the Americans is misleading. Actually, he may have put in more energy in the form of motor fuel than the Chinese farmer, so that in terms of gross energy input, he may even have to put in more energy in the cultivation of an acre of land than the Chinese. But, in terms of human labor, the amount which the American farmer puts in is very small, and the extra human labor thus saved could be used for the production of items which enable him to lead a more luxurious form of life and to build his art and culture, which cannot be measured in terms of energy.

### Animal and Man

There are two major uses for which animals may be employed by man: power and food. While man may survive on a vegetarian diet alone, it is generally agreed among nutritionists that a people fed on a generous supply of animal proteins are as a whole healthier and more aggressive than those who survive mainly on a vegetable diet. According to this view, an ample supply of animal food should be one of the chief objectives of agriculture. And yet, at least half of the people on earth are deprived of this privilege. Aside from religious considerations, which in the final analysis may still be due to economic pressure, the reason is simple. As long as animals are, like man, dependent on the green plant for food, animal products are always more expensive than plant products. In obtaining his food indirectly from the plant via the animal, man has to pay the price of the middleman. The amount of land required to support one dairy cow in the United States varies from one to 10 acres, and on the average, let us say, 2 acres, obtaining thereby 1,350,000 calories in the form of milk, which amounts to 675,000 calories per acre as against some 4 million calories obtainable from the two crops of grains and potatoes produced thereon. The contrast is even more marked when the land is devoted to the raising of beef cattle and poultry. One acre of land produces only 0.21 million calories in the form of eggs, and 0.1 million calories in the form of beef. In order that every country may reach a dietary standard similar to that of the United States, the animal products of the world would have to be at least doubled, which would in turn require a twofold increase in the area of pasture-land as existent today. And this increase in pasture-land would cause a diminishing of crop land corresponding to about 15 times its size, since one acre of land devoted to the production of grains yields 6 to 7 times as much food energy as that devoted to the raising of dairy cattle.

So long as the population of the world does not decrease, so long as the present practice of agriculture cannot be expected to give significant increase in crop yield, the competition between man, animal, and plant for land area will forever be a barrier to providing ample animal products for human consumption.

In his ascent from parasitism to symbiosis, man domesticated animals to supply power for his farm, thus ridding himself of the heavier burdens. As man becomes more and more civilized, the animal is in turn replaced by the machine. How does the animal compare with the gas engine as a converter of energy? For muscular work in man and animals, a gross efficiency of 25 percent may be realized. That is, of the amount of energy in the form of food given to the animals, 25 percent of it may be realized in the performance of work, which is about the best that a diesel engine can do. For the working animal, however, over a period of 24 hours, the efficiency is considerably lower, and is of the order of 10 percent. But even this low figure is better than the performance of the steam engine, which is only 7 percent efficient, and is equal to the performance of the gas engine. Based on these figures, the draft horse is at least as efficient a "machine" as the tractor. To this must be added the advantages possessed by the horse: the ability to repair itself, to respond to changing rates of performance within short periods, and the possession of a certain degree of intelligence.

For this reason, the animal is a better source of farm power in densely populated countries with small farm holdings, such as in China, India, and Japan.

If the animal possesses so many advantages over the gas engine, and is at least as efficient in the performance of work, why is the animal being extensively replaced by the gas engine in some countries such as in the United States? The answer lies again in the competition between plant, animal, and man for land surface. While the animal is as efficient as the gas engine, the former, being dependent on plants for fuel, must rely on land area for its maintenance so that a part of the land it helps to cultivate goes to the maintenance of itself. Evidently the animal is not suited for large-scale operations in which case the proportion of land area devoted to the maintenance of the animals may become a serious economic factor. On the other hand, the gas engine consumes fuel in concentrated form, transported to the farm from a single oil well on perhaps an acre of land from which is supplied the fuel for thousands of farms. In a country rich in mineral oil, the horse is no competitor with the gas engine. Conversely, in a country without oil resources, though the land holdings may be large, mechanization of agriculture is not necessarily economical even when power alcohol may supply the fuel for the machines, since alcohol comes from the plant, which in turn requires large land surfaces for its cultivation.

### Machine and Man

As the domestication of plants and animals distinguished the age of agriculture, so does the utilization of land for the fuel of the machine characterize the age of industry. The power and raw materials of industry come from two sources, the organic and the inorganic. Of all the sources of fuel for power, coal and oil remain the cheapest, and certainly the most generally employed, not excluding water power. While coal and petroleum are generally classified as minerals, they are of organic origin deposited for us in the geological ages. Being of organic origin, they are subjected to the same drawbacks as the agricultural products; that is, the energy stored therein is only an insignificant fraction of the radiant energy which was available to them. At any rate, the world's supply of coal and petroleum is limited by the extent of their deposition on the one hand, and the enormous time required for their formation on the other. The world's known, readily available petroleum deposits may serve us for some thirty-five years at the present rate of consumption, while the coal deposits of the world can last for some six thousand years. What about relying on the land for the production of fuel for the machine? Of late, much emphasis has been given to this problem, both in the United States and in China. In the United States, the movement was originated by the Farm Chemurgists for the utilization of farm surplus. In China, the movement was initiated out of dire necessity. An analysis of the problem will make it clear that such a practice would involve competition between man and machine for land area, and while under special conditions a small part of the fuel may be derived from the land, in the long run the practice of obtaining fuel from farm land for the machine has no great future.

Let us take first the case of a country like the United States. An oil well on an acre of land, say in Oklahoma, may have an ultimate production of 3,500 barrels of crude oil, yielding 1,000 barrels of gasoline. The same acre, if planted to corn, would only give a quantity of alcohol equivalent to three barrels of gasoline. At this rate, three hundred years are required for the same acre of land to produce fuel in the form of power alcohol as compared to the five to ten years for the production of gasoline. True, that acre of land can be used over and over again for the production of power alcohol if so desired, while the petroleum deposit will ultimately be exhausted. But three hundred years is a long time to wait for the economic functioning of the machines. Furthermore, as some writers put it, a surplus of one billion bushels of corn would sound tremendous to the farmer, but it would only yield 250 million gallons of alcohol, enough to run U. S. cars and trucks for about three weeks.

So much for the possibilities of obtaining power from land in a country with agricultural surpluses. Let us turn now to the problem in a country which, out of dire

necessity, is resorting to the use of power alcohol for the functioning of her war machine. Economists, chemists, and militarists of China have urged the use of power alcohol for China's motor vehicles, and plant after plant has been set up for the production of this material during the six years of China's war with Japan. The irony of this lies in the fact that such a practice, if on an extensive scale, will force the Chinese to choose between starving the trucks or starving themselves. Assuming a total of 25,000 cars and trucks running per day, the amount of alcohol consumed, on the basis of 30 gallons per car, would be equivalent to 7,500 acres of land area, making a liberal allowance of 100 gallons of alcohol per acre. For the year, the land area required would be 2,700,000 acres, which is roughly one percent of the total cultivated area of all China, and is about six percent of the total cultivated area in "free China," the food production of which is barely sufficient for human consumption.

The matter may be different in peacetime China. The import of gasoline to China in 1932 was about 3 million gallons, equivalent to 5 million gallons of alcohol which would require a land area of 50,000 acres, which is only 0.2 percent of the total cultivated area of China. Even if the gasoline consumption should be increased five times more than the pre-war figure, the amount of land required for the production of power alcohol is only of the order of one percent of the total cultivated area. If a mixture of alcohol and gasoline is used, the land area required can further be reduced.

For a country relatively undeveloped industrially, and for a country with food surplus but without petroleum resources, power alcohol may be a temporary solution to the fuel problem. But, as industry is developed, competition results, sooner or later, not only between man and machine for fuel and food, but also between one machine and another.

From these considerations, the power problem cannot be solved by the utilization of farm land for the production of power alcohol, or vegetable oil, or any such products, but the solution has to be made independent of the land. The more immediate solution is, of course, the hydrogenation of coal, and the extended use of hydroelectric power, but the ultimate solution will perhaps lie in the direct utilization of the sun's energy and in the harnessing of energy from the disintegration of atoms.

### Man as Agriculturalist and as Industrialist

If the land is not to be relied upon for the power of the machines, can it be relied upon ultimately for the production of raw materials? The answer to this question depends on the kind of raw material and the length of time to be considered. As man advances from the agriculturalist to the industrialist and emerges into the age of science and technology, he continuously attempts to free himself of the limitations imposed upon him by the land and by the elements. He is forever striving to be independent of the land for the production of raw materials for his machine. In this quest for independence, man is making much use of the discoveries in his laboratory; because of this dependence of technology on the advance of science, the latter is the factor deciding whether certain raw materials may be produced synthetically or whether the land should continue to supply them. Within the last generation, man has been successful in a number of attempts in this direction, and in a very small measure he has even succeeded in the attempt to create an artificial environment for himself in weather-conditioned dwellings. He has been successful in the synthetic production of indigo out of mineral sources, in the fixation of atmospheric nitrogen, and in the large-scale manufacture of synthetic rubber. He has been particularly successful in the production of artificial fiber, rayon, and more recently, nylon, and a host of similar products which threaten to displace natural silk from the market. Is this tendency to replace agricultural products by synthetics a temporary and ephemeral boom or is it likely to continue and increase? We shall examine the future of natural silk against synthetics and that of the tung oil as examples.

For the production of 40 million kilograms (88 million lbs.) of silk, which was the total world production for 1935, 2 million acres of land are required for the cultivation of mulberry trees, which in turn requires in a

country like China, the amount of labor equivalent to 400 million man-days. To this must be added 20 million man-days for the care of the worms and 80 million man-days for processing. The land and labor involved are equivalent to having the entire population of Philadelphia working in the State of Delaware for the year round on the production of natural silk alone, while a chemical plant on a city block of space in Wilmington, employing a few hundred men, may turn out an equal quantity of synthetic nylon during the same time, leaving the enormous surplus of land and man for the production of other articles of industry, and for the attainment of a richer way of life.

Add to these considerations the uncertainties of the elements, of diseases and epidemics, and the difficulties involved in obtaining products of uniform quality, it is evident that the future of silk as against artificial fibers is not encouraging. But this does not mean that there is no room for the production of a limited amount of natural silk in countries with a dense population, and for countries which are less industrially developed. As a handicraft, on a family production scale, natural silk will still have its place in the near future and may still have a market in the more industrially developed countries, as an item of novelty and luxury. But the future of natural silk as an industry on any large scale is doomed.

On the other side of the question, there is the example of tung oil, which has long been a Chinese monopoly. In recent years, experimental plantations were made in the southern part of the United States without much success. In spite of the optimism of the small group of landowners along the gulf coast, the concensus of expert opinion is perhaps not in favor of the attempt. The urgent need of the oil and the difficulties in obtaining the product, especially during the past few years, have forced chemists to adopt substitutes for tung oil, mainly with processed castor oil. But the problem is far from being solved. In so far as the substitute comes from the land, as does castor oil, it suffers the same drawback as does the product which is being substituted. While the treated castor oil or any other oil such as oiticica oil may even possess advantages over tung oil in certain particular aspects, they cannot be entirely satisfactory as substitutes for the general use to which tung oil is being put. Besides, these oils have other uses than as tung oil substitutes, in their own right, and the limited area of Brazil and other South American countries cannot be entirely devoted to the production of vegetable oil alone.

Man, in his transition from the savage to the farmer, learned the use of land for the production of food for his activities and fuel for his home. As he passed from an agriculturalist to an industrialist, he made additional use of his land for the production of power and raw material for his machines. Man is now on the verge of a new era, the age of technology, and is gradually learning, through his better understanding of nature, to obtain power and raw material directly from the inorganic elements through chemical processes, independent of the green plant. The thoroughness with which synthetic materials can replace agricultural products depends on two factors, the advance of man's scientific knowledge and the balance among many economic factors. At least in the near future, the replacement cannot be complete, and it is doubtful whether it ever can be complete, but the trend of progress is clear: for his industrial raw materials man is trying to rely more and more on synthetic materials out of air, water, and minerals, instead of relying on plants and animals.

### Alchemy and Utopia

If the tilling of land is symbolic of man's attempt to make fuller use of nature's gift, the toil of the alchemist marks the beginning of man's attempt to conquer his environment. And the remarkable progress made in the fields of science during the present century is the beginning of the fulfillment of the dreams of the alchemists. During the last decade or so, one discovery in the field of nuclear physics led into another, making possible artificial radioactivity and the transmutation of the elements and culminating in the practical application of the cyclotron, popularly known as the atom smasher. The modern alchemist is not only able to fulfill the dreams of his predecessors, that of transforming quicksilver into gold, he has gone

far beyond. He has at his disposal means of unleashing energy from the atoms, which in time may be turned into practical application, furnishing sources of power for the machine independent of the green plant. This tool of the modern alchemist, though still in the stage of the dynamo in Faraday's day, promises to be of far more value to himself than was Midas' gold.

The chemist, in his search for the secrets of matter, has produced materials of synthetic origin with which we are clothing and housing ourselves. The significance of these developments is far greater than the mere satisfying of human curiosity or the providing of man with a greater variety of materials for his frivolities. These discoveries herald the beginning of a new era much as the cultivation of the first grain of rice, or the introduction of the steam engine or the dynamo; they usher in the era of technology in which man may hope to be at least partly independent of the green plant (hence of land surface) for the supply of his raw materials as well as for the production of his food and power. We have seen the displacement of the indigo plant by synthetics of mineral origin, the capturing of atmospheric nitrogen independent of the plant and animal, and the very rapid substitution of artificial fibers for silk, wool, and even cotton, within the last few years. The time may not be far off when rubber plantations will give way to factories manufacturing synthetic rubbers, and when certain other agricultural products will be replaced by such materials as plastics and fiber glass.

Already the biochemists and the physiologists are isolating and even synthesizing for us vitamins and hormones which less than a decade ago were known to the layman only as letters of the alphabet. It is not mere wishful thinking that in the generation that lies ahead of us, we may understand enough about the fundamental process of photosynthesis of the green plant to be hopeful of liberating ourselves some day from the toil of agriculture as practiced now. Already much emphasis is being placed in this branch of biological research. The establishment of laboratories for photosynthesis at the Carnegie Institution and more recently at the Kettering Foundation, the groups of biologists, chemists, and physicists at Chicago and California cooperating on the investigations into carbon assimilation by the green plant and by bacteria, are evidences of growing interest in the problem of photosynthesis in America. Already great strides have been made in the last few years, and the time is not far off when we can be much better informed about the mechanisms of this process than we are now.

When that time comes, man will be independent of the limited two dimensional land area for the cultivation of his crops for food and power. He may, by using the earth as his crucible, the sun and the atoms as his furnace, and the air, soil, and oceans as his reagents, elevate himself from slavery to the status of a Titan. Man will then enjoy an age of abundance and prosperity, free from muscular labor and strife. He will be given a respite from his constant fight against his crops, his animals, and his machine for the limited land area. Until that time comes, however, man will still have to depend on agriculture as practiced at present for food and power. He will still not be freed from the constant struggle for space. This struggle can, however, be alleviated temporarily in certain ways, aside from the usual practice of improving the soil, crops, cattle, and the prevention of diseases, and the much advocated limitations on population growth. One of these is the more extended use of the seas and oceans in which are stored vast wealths of animals and plants, and about which the young science of oceanography may have much to tell us in the future. Another possible measure for the more economic use of land lies in the establishment of a world state in which a scientific and rational regionalization of agriculture may result in a more efficient production of agricultural products through fuller utilization of the natural distribution of climate and soils of the world, unlimited by artificial political boundaries between the nations.

# COME AND EXPEL THE GREEN PAIN

By NORMAN TAYLOR

SCARCELY forty years after Montezuma lost his empire to Cortes, the Church in Mexico began to worry about two rather disturbing phases of what the priests called Aztec idolatry. The Spaniards had been even more horror-stricken at the hecatombs of "ritual murders" on the *teocalli.* For under those extraordinary pyramids they found the enormity of this Aztec fanaticism, whose priests measured their zeal by the number of their victims' skulls. While the Conquest had stopped this atrocity, the Church was still disturbed.

It soon found that the beautiful symbolism of the Mass was being horribly distorted by other, if less bloody examples of Indian perversity. The good padres feared for the souls of their flock, if not for the prestige of the Church itself. This drove them into heroic attempts to stamp out such idolatrous practices—a campaign doomed to failure although it lasted over two hundred years. They were tilting against a graftage of Aztec lore upon Roman liturgy, but this is still rife in Mexico, particularly in the case of two plants—the ololiuqui and peyotl.

The persistence of these Aztec cults is matched only by their extraordinary hold on the Indians and by their antiquity. Their pre-Conquest history may always be shrouded in that medley of folklore and races, of which Cortes saw at Mexico City only the fantastic finale. But ololiuqui and peyotl were working their quite magical charms for centuries before that incredible Conquest, when a handful of Spaniards captured an empire.

That the Aztecs should have confused the Mass with their own magic does not surprise us quite so much as it did the dignitaries of the Church. The neighboring Mayans in Guatemala still do so in the murky gloom of that midnight Christmas service at Chichicastenango. And Elsie Clews Parsons in her extraordinarily understanding book, *Mitla—Town of the Souls,* tells us how this interweaving of Christianity and native lore permeates everything from birth to death, including the use of ololiuqui. And not so long ago some Indians in Wisconsin were tried by the United States Courts for their use of peyotl, sent to them from Texas. The chief defendant was acquitted, on the ground that the peyotl cult was "religious"—as in fact it may have been, considering that the Indians took peyotl as the faithful do communion.

In its desire to purge the Indians of the black magic of ololiuqui and peyotl, the Church left us the only writing we possess of the early use of either of these plants. For Prescott mournfully reproaches Cortes with the destruction of practically all Aztec records, a loss equally mourned today by every anthropologist and by many botanists. But the records of the Church show how potent were these plants, and how widespread their use, quite apart from their impact upon Church doctrine. We hear of both plants from a series of writings put out to instruct priests in the technique of the Confessional. One of them was called *"Camino del Cielo"* —the Road to Heaven. The object was to find out how much the "evil" had spread and where it was doing the Church the most harm. The questions illuminate not only the principal objects of them, but the life of Mexico:

"Hast thou eaten the flesh of man?"

"Hast thou eaten the peyotl?"

"Do you suck the blood of others?"

"Do you adorn with flowers places where idols are kept?"

"Do you predict future events by reading omens, explaining dreams, or tracing circles or figures in water?"

"Have you eaten the seeds of ololiuqui?"

And so on. The catechism was extensive and continued for over two centuries, for one of these instruction books was printed as late as 1760 by Fr. Bartholomé Garcia. To the somewhat bewildered Indians this ritual must have been a bit confusing. Had they not always used ololiuqui and peyotl, was not divination traditional, and could the visions caused by these two plants be other than good? One of them seems to have sensed the fact that it was better to make a

clean breast of it, at once. This sinner, back in 1634, made a confession which was reported by Bartolomeo de Alua in a book published at Mexico City: "I have believed in dreams, in magic herbs, in peyote [peyotl], and in ololiuqui, in the owl, . . ."

The admission of his traffic with the owl was as damaging as addiction to the two plants, for the Church reserved to itself the prerogatives of death. And, as Miss Parsons points out, the Aztecs considered the perching of an owl on a sick man's house a portent that, even today, no Indian at Mitla cares to ignore.

Quite apart from their use in Indian magic, these two plants have been and are still used for their effects upon the mind and nervous system of a people long inured to hardship. In the peyotl is found a potent alkaloid that interests modern science and led Havelock Ellis to use it in an experiment upon himself. The plants are botanically unrelated but their effects are similar enough to justify their linkage by Mexican clerics. And there is sound reason for the use of both ololiuqui and peyotl today.

This is scarcely surprising, for perhaps nowhere has the passionate desire to escape from reality been so developed, and so necessary, as in Mexico. One can not help noticing it, no matter from what direction one enters the country. For instance, in leaving the clean efficiency of Laredo, one meets almost too suddenly the dramatic squalor of the desert road to Monterrey. Not the industrial squalor of cities, but that immemorial stolidity of those to whom nature has been less than kind. Only with luck, and just a little foresight, can these peons hope to wring from that cactus waste enough corn and cattle to carry them through the brilliance of the rainless winter. Here are the grim realities of desert life, scarcely mitigated by rare gas stations, and perhaps only aggravated by the stream of American tourists.

For hundreds of years before we began to "do" Mexico, and over an area as large as Texas, which once belonged to them, these Indians of northern Mexico have fought for a precarious living. They may be assumed to have benefited by the influence of the Spaniards and the Church, and always they have lived close to their incomparably stark mountains—towering, treeless, to the blue immensity of the sky. But these scarcely seem to have been enough—the struggle is too bitter, the compensations too meager. For them the Gods created peyotl, or so they think, and who are we to deny the divinity of some Aztec deity?

If, on the other hand, one enters Mexico from Guatemala, what a different scene is unfolded. The anthropologists tell us that, racially, these Indians of southern Mexico are different from their Guatemalan neighbors. But the products of Oaxaca and Chiapas approach more nearly than anything in Mexico the incredibly colorful life of the Mayans of Quetzaltenango and San Marcos.

In spite of nature's apparent bounty to those Mexicans that face the Pacific, the Indians of Oaxaca are nearly as poor as those of the north. Their multi-colored tiles, basketry, glassware, silver-work, jade, woodwork, and their innumerable shrines are little more than a veneer of recent Spanish, overlaying deep strata of pure Indian. Ages before this shallow coating of modernism, their ancestors sought just as passionately as their brothers in the north for some mitigation of the disenchantments of life. This may seem strange to those tourists who think of Mitla as the very mecca of enchantment compared to the capital. But to the Indian, the ruins of Oaxaca are no compensation for the age-old problem of some flight from reality. For them it has been ololiuqui, just as peyotl is for the Indians of northern Mexico. Trade in both products exists with the result that each is now known over much of Mexico. But the origin of ololiuqui in and near Oaxaca, and peyotl near our Texas border, seems well established.

## I

Throughout southern Mexico, but especially in Oaxaca, there scrambles a vine looking not unlike an anemic morning-glory, to which it is closely related. But it has a woody stem and so clambers over cactus hedges or old walls with more permanence than our common, garden morning-glory. After somewhat persistent attention by botanists, from Linnaeus in 1759 to Harvard University in 1941, the nine former

names of this plant have now simmered down to the final one, which is *Rivea corymbosa,* a Latinism here injected to quiet the apprehension of former colleagues, and for the sake of what is called "the record."

It has the heart-shaped, pointed leaves of most morning-glories, but the whitish, funnel-shaped flowers are hardly more than an inch long. These are followed by a small, fleshy fruit, in itself quite useless, but containing a single, lentil-like seed. This, and sometimes the plant itself, have been known as ololiuqui ever since the Conquest, and long before. The Aztecs may have used the name for other plants, but commonly they applied it to the seeds of *Rivea corymbosa.*

As in so many New World plants, our first record of ololiuqui came from the contemporaries of the conquest of Mexico, often priestly historians. Quite naturally these ecclesiastical chroniclers were outraged to find that the use of ololiuqui was a ritual and that it had a god of its own, worthy of veneration if one wished to benefit by miracles. One of these Spaniards, Francisco Salverio Clavigero, had this to say about the profane use of the seeds:

> Besides the usual unction with ink another extraordinary and more abominable one was practiced every time they [the Aztec priests] went to make sacrifices on the tops of the mountains, or in the dark caverns of the earth. They took a large quantity of poisonous insects . . . , burned them over some stove of the temple, and beat their ashes in a mortar together with the foot of the ocotl, tabacco, the herb Ololiuqui, and some live insects. They presented this diabolical mixture in small vessels to their gods, and afterwards rubbed their bodies with it. When thus anointed, they became fearless to every danger. . . . They called it Teopatli, or divine medicament, and imagined it to be a powerful remedy for several disorders; on which account those who were sick, and young children, went frequently to the priests to be anointed with it.

Joseph Acosta, writing in 1590, had much the same opinion, but embellished the ritual by adding: "By means of this ointment, they become witches and did see and speak with the devil. The priests being slobbered with this ointment lost all fear."

That a narcotic like ololiuqui should be venerated by the Aztecs, and have its own god which was worth invoking, is entirely in keeping with the experience of other primitive peoples. And in propitiating the god of ololiuqui the Aztec priests sometimes used far more colorful methods than the gruesome witches' broth cited above. Gathering their gorgeous native flowers, they would repeat the formula: "Come hither, thou, the yellow and ardent red one; come and expel the green pain, the brown pain, which now wishes to take away the life of the son of the Gods!"

Whether gruesome or flowery, we see in these invocations pure Aztec ritual, uncontaminated by Rome, and as yet showing little to make the Church fear that ololiuqui would ever interfere with the spread of Christianity. But the Church misjudged the veneration in which the plant was held, and should certainly be forgiven for not guessing that the Indians would soon be mistaking the Virgin for an Aztec deity. In fact, a few of the lower orders among the Spaniards may also have become contaminated by this blasphemy. For some, who must have used the seeds, were soon committing the enormity of calling them, *semilla de la virgen.*

As to the veneration in which the plant was and still is held, there can be no doubt. For the seeds have a three-fold function—as a narcotic, a medicine, and as part of the ritualistic hocus-pocus of divination. Among all but the most ignorant Indians of southern Mexico the latter virtue of ololiuqui has waned. As a medicine, in spite of the Department of Public Health at the capital, it is certainly still in use, mostly in remote hamlets such as that in *The Forgotten Village.*

But its great use, before, during, and ever since the Conquest has been as a narcotic which is supposed to confer peculiar powers. As one old chronicler puts it ". . . they consult it as an oracle in order to learn many things . . . especially those things which are beyond the power of the human mind to penetrate. . . ."

Even today we share the ignorance of those Indians, because the narcotic properties of ololiuqui are, still, something of a mystery, for unlike most others, nothing is known of the chemistry of the alkaloid and glucoside recovered from its seeds. Whatever the active principle, it seems to be most effective, for it induces ultimately a kind of hypnotic sleep or coma. At first there are hallucinations, sometimes preceded or punc-

tuated by giddiness, but as in the Indian hemp and peyotl, always leading to a kind of euphoric bliss. Most Indians who have used ololiuqui and peyotl admit that subsequent visions are pretty much the same from both plants. Because of this the final stages of intoxication from ololiuqui are best understood by comparing it with peyotl, the precise effects of which are far better known.

The Aztec dosage of ololiuqui may never be accurately determined, but the present one is almost wholly dictated by Christianity. Miss Parsons relates how potent a certain number is at Mitla where the Indians still confuse ancient lore with the Church. An Indian woman will bake thirteen tortillas, treasure thirteen beans, store thirteen jars of tepache—all in imitation of the number at the Lord's Supper. And of ololiuqui they similarly take mostly thirteen seeds soaked in water. Sometimes an alcoholic beverage is used, but it appears to add nothing to the narcotic effectiveness of the seeds, although it may mask their bitterness, which is considerable.

Unlike peyotl, ololiuqui exhibits the phenomenon of the lone drinker. Mostly used at night, it is practically always taken alone, and as one old historian puts it, always in a place "where he cannot hear even a cock's crow." In the loneliness of some adobe hut the seeker after its effects completes his brief flight from reality, lasting about three hours, and returns none the worse to the drabness of his real world. Dr. R. E. Schultes, the leading modern authority on ololiuqui, is emphatic on this lack of serious sequalae. He writes that its use "is followed by few unpleasant after effects," although, like any other drug, excessive use may be disastrous or even fatal. In modern times it rarely or never is.

In the use of ololiuqui, other than as a narcotic, medicine and divination seem not tc be far apart. The seeds are in no modern pharmacopoeia, but in many native ones. Beyond some fancied, or maybe real, value as a pain-killer the ololiuqui is quite innocent of therapeutic effectiveness. Its pain-killing properties, however, have long been surmised, and Dr. Schultes suggests their subsequent investigation. But there is no question whatever about the hold that ololiuqui has on the imagination of those Indians who think that it will not only cure their ills but tell them things "which are beyond the power of the human mind to penetrate."

Upon this credulity plays the *curandero*, or medicine man. Is he, too, merely an amiable simpleton, or perhaps a misguided but authentic relic of old priestcraft, or is he just a plain rascal? It depends a lot upon the altruism of a man a little too strategically placed to remember that virtue. The fact is that he generally buys the seeds for a few centavos, charges his patients far more, and in the process invests them with a magic power upon which one can scarcely put any price. Maybe he believes it; certainly his clients do.

Apparently the curanderos of today differ little from their spiritual ancestors, the witch-doctors. Just as valid now, as when written in 1629, is Alarcon's description of how a patient fares from his curandero:

> Chronic illness, kinds which the curanderos have pronounced incurable with ordinary medicines, are attributed to witchcraft and . . . , according to their belief, cannot be cured if the one who has cast the spell does not break it. This is the usual way in which the doctors make profits and wreak much injury with the satanic superstitions surrounding ololiuqui. . . . The doctor immediately attributes the illness to witchery. . . . In order to aid the doctor, the patient relates his suspicions. The deceiving doctor immediately orders the use of ololiuqui, and the patient follows the doctor's words as though they were the words of a prophet or of an oracle. . . .

Could any modern quack want more? The simplicity of the method is unique. Narcotizing a patient with ololiuqui is far cheaper and lots easier than the elaborate hocus-pocus that passes for quack psychotherapy. Add to this the fact that curanderos offer equally valuable services in finding lost articles, guessing the outcome of illness, or battles, and other imponderables, and one has a set-up to whet the appetite of modern medical imposters.

It may be that the only honest use of ololiuqui today is by those poor, stolid Indians who take it frankly as some mitigation of their none too zestful life. As for its use by curanderos and in divination, the less said the better. Certainly no modern appraisal of such practices can match the wisdom of that penetrating priest, Jacinto de la Serna,

who wrote long ago, "It is not without concern that Christian priests see the facility with which the devil works among these people. . . ."

II

No desert stroller can help falling a little under the spell of the cacti, even if they provoke many questions. Why should they stretch fantastic arms to heaven like the sahuaro, or wallow, barrel-like, in spiny ferocity, like the melocactus? Of what use is the white, ethereal ghostliness of the night-blooming cereus, or the provocative fez of the Turk's-head? Why don't they have leaves like other plants, and most of all why their utterly unapproachable prickles? And why did one botanist so aptly call them The Fantastic Clan?

Such questions could be multiplied about thirteen hundred times, for that is the approximate number of different sorts of these weird denizens of the desert, all but a handful of which are confined to the New World. Few are of any practical use, although some, like the tuna, yield edible fruits; others, a little water for thirsty travellers; a few are used for hedges; Aztecs made needles from the spines of one of them; the nopal is still, although rarely, grown for cochineal; a very few make substitute cattle food; and scores are cultivated by fanciers, more for their interest than for their beauty. In spite of this, neither their enormous development in tropical deserts, nor the diversity of their forms, can shake most of us out of the conviction that the cacti are among the most useless of all plants—perhaps fit only for destruction, like the rank prickly pear in Australia.

But there is scarcely an Indian in Mexico, who would agree with us. No matter how many deep, cactus-clad barrancas he may be forced to detour, nor how often his tattered blue jeans become even more shreddy from their cruel spines, he still would resent their destruction. For he, far better than most of us, knows that one of the strangest, and to him the most precious, of all the cacti is the peyotl. It actually is unique, for not one of its grotesque allies, from Kansas to the Argentine, can approach the peyotl in the veneration in which it is held. For it is the only one of the huge cactus family that has so far produced an alkaloid which will mitigate the intolerable impact of reality.

Peyotl, in spite of this, is the least impressive of all the cacti, so inconspicuous that one cannot help speculating on who first noticed it and who discovered its properties. Such speculation is useless, for it was known ages before the Conquest, back in some dim period for which there are no records. But that did not prevent some inquisitive Indian from unwittingly starting a new plant cult. It still survives.

The cause of it all is *Lophophora williamsii,* which is the Latin name of the peyotl. It is a curious cactus, seven-eighths of which is buried in the ground. This submerged part is not unlike a parsnip in size and shape, with a single tap-root. Upon this apparently stealthy desire to hide itself in the ground, Francisco Hernandez put a most charitable interpretation. Writing in 1576, he says that on account of its magic properties, "this root scarcely issues forth, but conceals itself in the ground, as though unwilling to harm those who may discover it and eat it." That is one of the first records, incidentally, of the potentialities of peyotl, and it was written by a physician.

The only part of the plant to appear above ground has led to not a little confusion. For the top looks like a cluster of small, button-like mushrooms, and many, less observant than Hernandez, have frequently mistaken them for mushrooms. To further complicate the picture there actually was a narcotic mushroom in ancient Mexico, recently identified and appropriately christened in proper Latin, but its use is minor and it should no longer befog the history of peyotl. But it does, for the error is very old and at the time of the Conquest peyotl was often called the "Sacred Mushroom."

That error left a legacy that generated some later confusion. In Texas, where the peyotl is also native, the small mushroom-like buttons came to be called mescal buttons, which is singularly inappropriate, for mescal is an alcoholic beverage of Mexico and bears no buttons. In the United States, however, mescal buttons will probably always be the name for the peyotl, and mescaline is still the proper term for the chief alkaloid found in these curious dried cacti.

To call them "buttons," is, to all who never saw them growing, perfectly natural. Only a comparatively few Indians knew that this parsnip-like base of peyotl, was topped by a ribbed summit, that unlike most cacti it was spineless, and that among these ribs were button-like growths, bearing a small, rose-tinted flower surrounded by a tuft of whitish hairs. These grayish-brown button-like growths, which average a little less than two inches in diameter, look, when dry, very much like a shrivelled mushroom. It is in this form that they are sent to the capital, and it is only in the form of these "mescal buttons" that most of our own Indians ever see peyotl; here often called peyote.

The plant is confined to northern Mexico and adjacent Texas, is never very abundant, and may some day be exterminated because its collection has gone on from remote antiquity. It must once have been pretty common in the state of Coahuila, for in 1692 the priests and the Indians there seem to have joined hands in naming a mission *El Santo de Jesus Peyotes*—a variant plural of peyotl. That a mission could ever have been so named is far more incongruous than to see today a Unitarian church named for the Virgin. It was even worse, for the Church, about a hundred years earlier, had thundered against the enormity of calling peyotl "God's Flesh." No blasphemy could have been greater, although the Indians then, and even today, could scarcely pay a higher tribute to the Mass. For peyotl is venerated, and used, with all the mystic exaltation of some sensitive young priest, who for the first time officiates at the Elevation of the Host.

III

That a cactus could cause such incongruity would be unthinkable if the peyotl did not contain mescaline, which is certainly one of the most extraordinary alkaloids found in the plant world. Because of this, and long before the Conquest, Aztec priests were venerating certain plant cults, notably the peyotl, and doing it with ritualistic rites that made the Church shudder. These "heathen" priests even had a ceremony which reminded the Spaniards of the Christian communion. Diabolical as it seemed to them, "how," says Prescott, "could the Roman Catholic fail to recognize the awful ceremony of the Eucharist?"

The gathering and use of peyotl today still reminds us of some Black Mass, overlaid by Indian lore, and fundamentally dictated by what mescaline will do to the brain and nervous system. And because it is gathered and used by several different tribes in northern Mexico, the ceremonies differ somewhat. Also, to use here the different vernacular names for the plant would be to confuse something that is really quite simple.

One tribe begins the collection of peyotl in October, and those who are to gather it, before starting on their ten day journey, are feted by the burning of copal incense. Thus consecrated, they proceed to the gathering grounds, upon which a cross is erected. When the plants are first approached, the more devout will cross themselves, in the name of the Father, the Son, and Holy Ghost—the latter abstraction being, to the Indian, the peyotl. Flights of arrows, discharged right and left of the plants, are to warn off evil spirits. During the expedition, which in another tribe takes forty-three days, no salt or paprika is eaten and all refrain from copulation. Many paint their faces and decorate their hair and hats with feathers to indicate devotion to their special gods.

Upon their return, the villagers welcome them with music and dancing. Their precious hoard is reverently placed at the foot of the cross and sprinkled with a mild alcoholic beverage—often tiswin or pulque. A sheep or ox is sometimes sacrificed to peyotl the next day, and one gets some idea of their relative value by the gatherers once charging a sheep for a single plant, root and all, with its "buttons."

Then begins a ceremony, perfectly justifying an old chronicler in calling peyotl *raiz diabolica,* the devil's root. Today, in deference to Christianity, the ceremony starts after sundown on Saturday, and ends about noon on Sunday. Those who are to partake sit in a circle in a sacred tipi, or on the ground, which has been well brushed for the purpose. There is always a flickering fire. After an opening prayer, each is handed four dried "buttons," or in some tribes slices of the root-like base. After chewing, and spitting out the first bitterish extract, the re-

maining pulp is rolled into a pellet and swallowed at once. In three hours the hallucinations begin. Of these Lewin says, "they are of such a special nature and so superior to reality, so unimaginable, that the victim believes himself transported to a new world of sensibility and intelligence."

Certainly no stolid Indian has ever been really articulate as to just what peyotl does for him and fortunately it does not matter. We can the better postpone, therefore, an account of its peculiar properties to the more lucid explanation of modern doctors and Havelock Ellis. But from remote antiquity these Indians, as well as many in the southwestern United States, have their regular peyotl services, which, today, often coincide with saint's days.

It seems inescapable that they never dissociate its narcotic properties from divinity. No one knows in how many remote Mexican hamlets this circle of people, who seek some flight from reality, think of it truly as the gift of God. In some tipis, murky in the flickering firelight, there is an altar upon which peyotl is consecrated as the Host, no doubt by some ancient Aztec rite, and subsequently taken as communion. In other communities a beverage is made from it and used as holy water to christen a child. Novices, taking their first peyotl, are fanned by an eagle's wing while this holy water is used to make signs on their foreheads.

In still other tribes, the peyotl rite comes nearer to an orgy than a service, perhaps induced by the addition of pulque. Here the root is ground up, mixed with pulque, and imbibed pretty frequently. To the music of a "choirmaster" and his instrumentalist they dance in a circle, singing an unearthly, quite unmusical dirge, without stopping or leaving the circle, often throughout the night. The padre Jose Ortega, who saw such a "service" nearly three hundred years ago, describes the end thus: "When the dance was ended all stood who could hold themselves on their feet; for the majority, from the peyotl and the wine which they drank were unable to utilize their legs to stand upright."

Peyotl, however, is pretty generally free from any stigma of debauchery, is rarely associated with alcoholic intoxication, and is not an aphrodisiac. These facts no doubt dictated the acquittal of an extraordinary defendant in a trial in Wisconsin—The United States vs. Nah-qua-tah-tuck, an Indian living on a reservation. This is far from where peyotl grows, but such is the hold of the plant on the Indians, that they regularly imported it from near Laredo, Texas, where it grows within sight of the International Bridge. Such shipments are illegal, but the Indians got their supplies by the not very subterranean aid of the parcel post. Hence Uncle Sam's interest in the case, to which he sent a battery of legal and pharmacological experts.

The Indian testified that far from being wicked, peyotl was divine, its use religious and before taking it the Indians "invoked God, begging Him to make all of them good and to keep them from evil." That invocation followed an attempt by all the Indians to keep out the evil spirits, by the simple method of drawing a line about the house. Several witnesses were called. They, too, testified: "that he ate the peyotl so that his soul might go up to God" and "that peyotl helped them to lead better lives and to forsake alcoholic drinks."

At the same trial Thomas Prescott of Wittenberg, Wisconsin, an American, testified that for seven years he had been a "priest" of a joint society known to him as the Union Church Society, and to its Indian members as the Peyote Society. At weekly services the parishioners either ate peyotl or took it as tea, and apparently with much benefit, for, "they gave up drink, established themselves in regular homes, and lived sober and industrious lives." As for himself, the Rev. Prescott testified, "it stopped me from drinking, and now since I used this peyote, I have been sober, and today I am sober yet." This was too much for the government experts, and Uncle Sam decided to go back to Washington where the records of this fantastic trial still moulder.

In spite of wandering as far afield as Wisconsin, the peyotl cult was originally endemic only in Mexico and the region adjoining it in our Southwest. Today the Apaches, Omahas, Kiowas, Comanches, and many other tribes all use it, in spite of a United States law against it. All of these know it only in the form of "mescal buttons" which

they import from Mexico and the Rio Grande region of Texas. They have many modifications of the peyotl ritual, practically all religious, one of them closing with the song, "This is the road that Jesus showed us to walk in."

All their testimony, and most of the records from the Conquest insist that it is not habit-forming, nor does it usually do any physical damage to those who use it. Like the Indian hemp and ololiuqui, there is thus no real addiction problem, but as in any other narcotic, prolonged over-dosage can bring disaster. But centuries of use, although admittedly confined to only a few million people, has left the peyotl with a reputation unique among more dangerous narcotics. Its effects, so far from being degrading, seem quite the reverse. You could make no Indian understand that peyotl was ever a moral problem, in the reformer's sense of that word. His answer, if he were generally articulate, would very likely match those who are. And perhaps, who knows, he may be grateful to a particularly understanding and intelligent Englishman who tried peyotl on himself and left a very lucid record of his experience in the *Contemporary Review* for January, 1898.

IV

One Good Friday afternoon, in 1897, Havelock Ellis was sitting in his study in the Temple, reflecting upon a "new artificial paradise" which had come to his attention from Dr. S. Weir Mitchell, a distinguished physician. Ellis not only reflected upon it but had supplied himself with a collection of "mescal buttons"—the only name he knew for peyotl, as his supply had come from this country.

He determined to see just what mescaline did to the brain and nervous system, whether he could repeat the "brilliant visions" about which Dr. Mitchell had written, and lastly, whether he could remain lucid enough to write down his impressions. In the gathering gloom of a London afternoon he began his experiment, alone, with a fire in the grate, for he sensed that he "could see these visions best only in a room with flickering firelight, as with the Indians."

Having made a decoction of three buttons, "the full physiological dose," he drank it at intervals for two hours until there was none left. Perhaps that took more courage than it would today, for maybe he did not know that the Indians considered four buttons as a dose. In any case, he felt at the last drink of peyotl only a little faint and unsteady, which was not very alarming if it grew no worse. Generally he avoids mentioning, in the *Contemporary Review* article, any purely physical manifestations of its effects, for he had already written to the *Lancet* on this phase of peyotl intoxication. At first, beyond the faintness, nothing at all happened, but then, very gradually, pale violet shadows floated over the page he was reading. These were intensified by closing his eyes, sitting there in the darkened room with only the flickering firelight.

Later in the evening, the visions "became distinct but still indescribable—mostly a vast field of golden jewels, studded with red and green stones, ever changing. This moment was, perhaps, the most delightful of the experience, for at the same time the air around me seemed to be flushed with vague perfumes, producing with the visions a delicious effect."

At about this stage he felt "a tremor of the hands, which, later on made it almost impossible to guide a pen as I made notes on the experiment; it was, however, with an effort, always possible to write with a pencil." He, like numerous others, felt what Lewin has so aptly described as "a kind of removal from earthly cares and the appearance of a purely internal life which excites astonishment." He saw indescribably beautiful colors and forms, but the latter "never resembled familiar objects."

Such effects, as seen through the eyes of this intelligent recorder, must appear to the stolid Indian as even more fabulous. Changes of sense, hearing, color, perceptions, taste—how could they fail to denote divinity to those Mexican Indians, who, poles apart from Havelock Ellis, were united for that one afternoon, in the ecstasy of pure enchantment.

Ellis did not exaggerate when he called peyotl an artificial paradise. He became so enthusiastic that he subsequently tried peyotl on an artist friend, but nearly "killed

him," by giving four buttons which, besides the visions, induced heavy breathing and numbness. Later he tried it on two poets, using his own dosage and taking careful notes on the effects. They matched or exceeded his own.

He sums it all up by saying it may be dangerous to weak people but gives wonderful effects to robust ones. "It may at least be claimed that for a healthy person to be once or twice admitted to the rites of mescal is not only an unforgettable delight, but an educational influence of no mean value."

More than thirty years later, Dr. Eric Guttman of the Maudsley Hospital, London, became convinced that mescaline was a plant alkaloid decidedly worth more investigation. He used mescaline, the pure alkaloid, rather than the "buttons" so as to control the dosage more accurately. In recognizing mescaline as the pertinent alkaloid of the peyotl, he rejected the suggestions of Dr. Lewin, of Berlin, who insisted that he had isolated another and more important principle of peyotl, and that it came not from *Lophophora williamsii*, but from another species, named for him *Lophophora lewinii*, a plant no longer considered distinct from peyotl. Having cleared away this pharmacological and botanical wreckage, Dr. Guttman was ready to study just what mescaline did to the mind.

He chose sixty people "of sound mind" who volunteered for the experiment. It is impossible here to retail the experiences of all those who contributed so much to our knowledge of what peyotl will do. But a few clamor for inclusion. One of them reported, after the initial intoxication had proceeded for a while:

> At first they were no more than indefinite, white clouds moving on a dull black background. Soon they became clearly defined, and resolved into an interlacing pattern of white lines. The background became a deeper and richer black, the lines themselves were exquisitely sharp, fine and delicate. I saw a human eye, some faces traced by the lines in their earliest stages, but for the most part the rich black background was covered by meaningless arabesques, never still, crossing and interweaving in an endless flow. Every line was duplicated, its outline repeated again and again, growing at each repetition fainter, until, infinitely multiplied, it receded into eternity. New color entered upon the scene. The white lines turned to yellow and orange, thickening until broad patches of brilliant color glowed against the black, always beautifully defined. Other colors appeared, a superb emerald green, iridescent as a humming bird's wings, red like the sound of a trumpet, a flaming orange, a vivid purple.

Another volunteer saw a heavenly body "which was glowing like an iridescent plum pudding suspended in the sky exactly a hundred miles above the earth." Lightning and snow-clad mountains appeared which seemed to demand that the former should strike. Then he saw his "plum pudding" had changed into an Aztec figure to whom "innumerable pairs of white uplifted arms" were stretched in supplication. "I looked again at him to see how he was proposing to respond to these supplications, and was surprised to see that he had changed into Dr. N., who was at the same time, God. He seemed about a mile high, and I saw him in profile, dressed in a long white robe or toga, like Caesar, participating in a triumph —a wonderfully majestic figure. In his extended right hand he held the lightning in a flickering sheath of electricity."

If a London medical student could mistake a colleague for God, under a controlled dosage of mescaline, perhaps the padres were right in thinking that Aztecs were doing precisely the same thing with peyotl four thousand miles away, and much more than four hundred years ago.

It takes little flight of the imagination to understand how ololiuqui and peyotl came to be what they are. For both of them have provided at least temporary release from the corroding curse of boredom, apprehension, and disenchantment. Perhaps the fortunate among us, who of course never suffer these evils, not only can understand, but may forgive, those patient Indians for their plea, "Come and Expel the Green Pain."

# A BOTANIST'S DOMINICA DIARY

## I. IN AND ABOUT ROSEAU

By W. H. HODGE

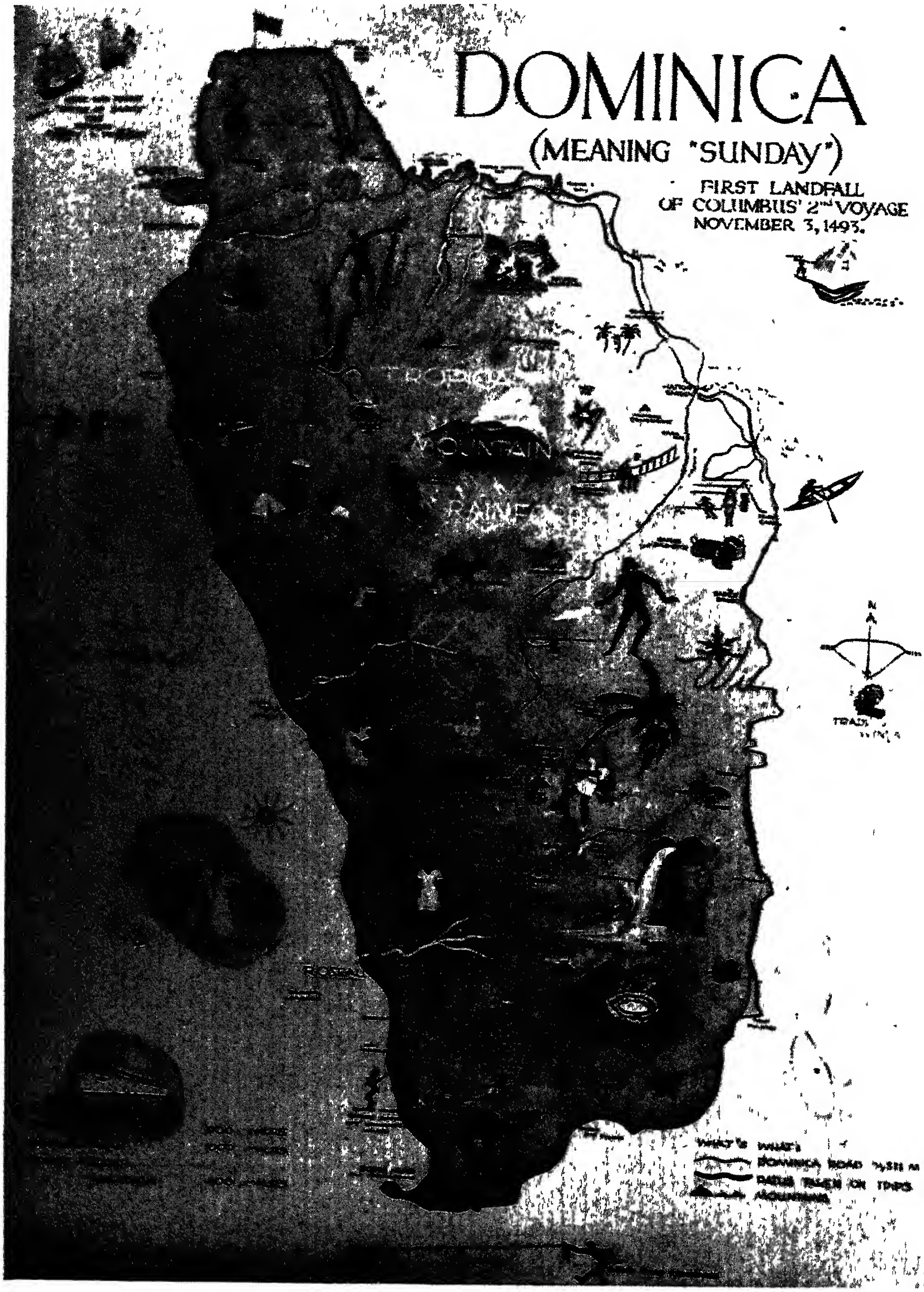
THE geographies included Dominica in the wet tropics; the travel guides warned of a rainy summer season; and when the deck steward casually remarked, after a fair passage, that there would be rain all right in Roseau, we actually were glad to receive the first welcoming Sunday deluge at anchorage. It was all a sort of promise, for an island that thrusts emerald-green peaks into blue-black clouds must catch lots of rain, and lots of rain means lots of plants—which are to a botanist what pie is to a small boy!

Botanists will easily see with what joy and excitement we looked forward to meeting the new and exotic flora of a real honest-to-goodness tropical isle. We sighted our island on a Sunday, the same day of the week on which Columbus himself discovered this paradise (Dominica was the first landfall, November 3, 1493, of his second voyage) and because of that fact called it Domingo, the Spanish for Sunday—and hence Dominica.

Roseau, the chief town of the island, which itself is little more than an overgrown vil-

NEW STREET, TYPICAL OF THE CLEANLINESS OF ROSEAU

THE LITTLE ISLAND OF DOMINICA IS ONE OF THE MOST HEALTHFUL OF ALL THE WEST INDIES.




DOMINICA: A PICTORIAL MAP

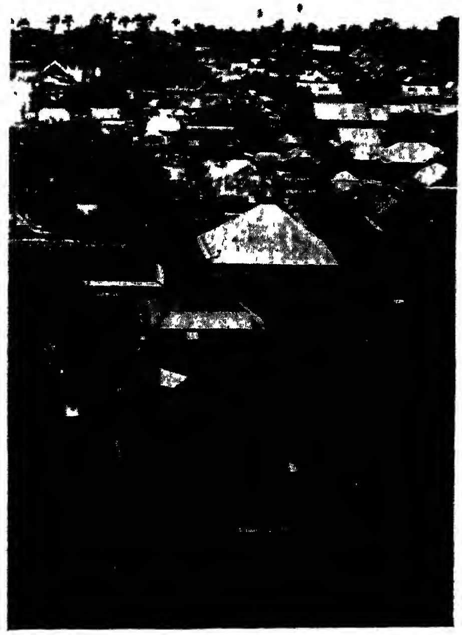
*By G. Stuart Hodge*

lage, is tightly jammed upon the only available level ground bordering the rugged Dominica coastline—a small delta hewn from the very mountains and tumbled down to the sea margin by the action of Roseau's lusty little river. The arrival of a steamer is the alarm clock that awakens the town. The white docks swarm with Negro folk eager to watch or to earn a coin. From this assemblage of humanity it was no task to find a porter—with a head and neck of steel! A steamer trunk filled with liquids, alcohol,

formalin, and other miscellaneous preservatives, is no feather for anyone's cap, and yet with this upon his head our black Atlas added a tightly packed valise plus two large cartons of plant-pressing materials; beneath each arm was placed a smaller package, and in each hand a suitcase just for balance! Thus assembled as a walking express he made his quarter-mile trek to our lodging place.

The departure of the steamer soon enables the turbulence of the town to settle out, and business, again quiet, focuses on the next arrival. The banana piles by the jetties have been depleted; bare-foot country peasants wend their way home to their palm-thatched mountain homes, or *ajoupas;* the fisherfolk while away their time offshore, where in the blue deeps flying-fish, red snappers, dolphins, kingfish, tunny, or jacks may be had for the fishing; and on the checkerboard of clean streets little groups of natives are quietly gossiping in the heat of the day, while the serenity of all is reflected in the chickens which wander from gutter to gutter picking up those few scraps that may have escaped the eyes of the early-morning sweepers For inhabitants of a tropical town, the people have been well schooled in the necessity of cleanliness, as the results show, for Dominica is one of the most healthful of all the West Indian isles.

Tiny Roseau has but one real attraction—her botanic gardens. In the beauty of this well-kept English park, which complements rather than vies with the natural vegetation of the surrounding mountains, one can find growing nearly all the outstanding representatives of the world's tropical flora. Indeed, the Roseau Gardens are famed as among the best in the West Indies; they possess particularly one of the finest palm collections in the Western Hemisphere. Within its gates are held many of the sporting activities of the island, for enclosed by a row of spreading saman trees is a well-kept greensward, site for weekly invitation cricket matches; here on Sundays the populace relaxes, enjoying the lush beauty as does a throng of New Yorkers set loose in Central Park. The larger part of the botanical establishment is at present set off for economic plant research designed to improve the productiveness of the island's agriculture through the introduction of new crops or of disease-resistant strains of the old.



THE TOWN OF ROSEAU

THIS SMALL CAPITAL TOWN IS LAID OUT ON A DELTA, WHICH IS THE ISLAND'S ONLY FLAT LAND.

The gardens early in the morning are a mecca for all life. The cassias, poincianas, and samans attract swarms of hummingbirds, blue-crested, green, and red-throated, as well as king bees, in size hardly distinguishable from the avian visitors. It is not unusual to see a mixed company of almost a hundred of these bees pirouetting among the branches of a single large flowering tree. The buzzing of wings in the air has an accompaniment of rustling in the ground litter, the dead leaves which, characteristic of evergreen trees, are ever-present on a tropic forest floor. Running this way and that always just beyond reach are beautiful blue-backed skinks, or ground lizards, interrogating the presence of the two-legged intruders with lightning-like protrusions of their tongues. In a region of bountiful insect and vegetable food it is no wonder lizards abound, and their ceaseless crashing around in the underbrush creates a racket far out of proportion to the creatures' size.

From the rear of the gardens rise the steep

BANANA LIGHTERS NEAR THE ROSEAU ANCHORAGE

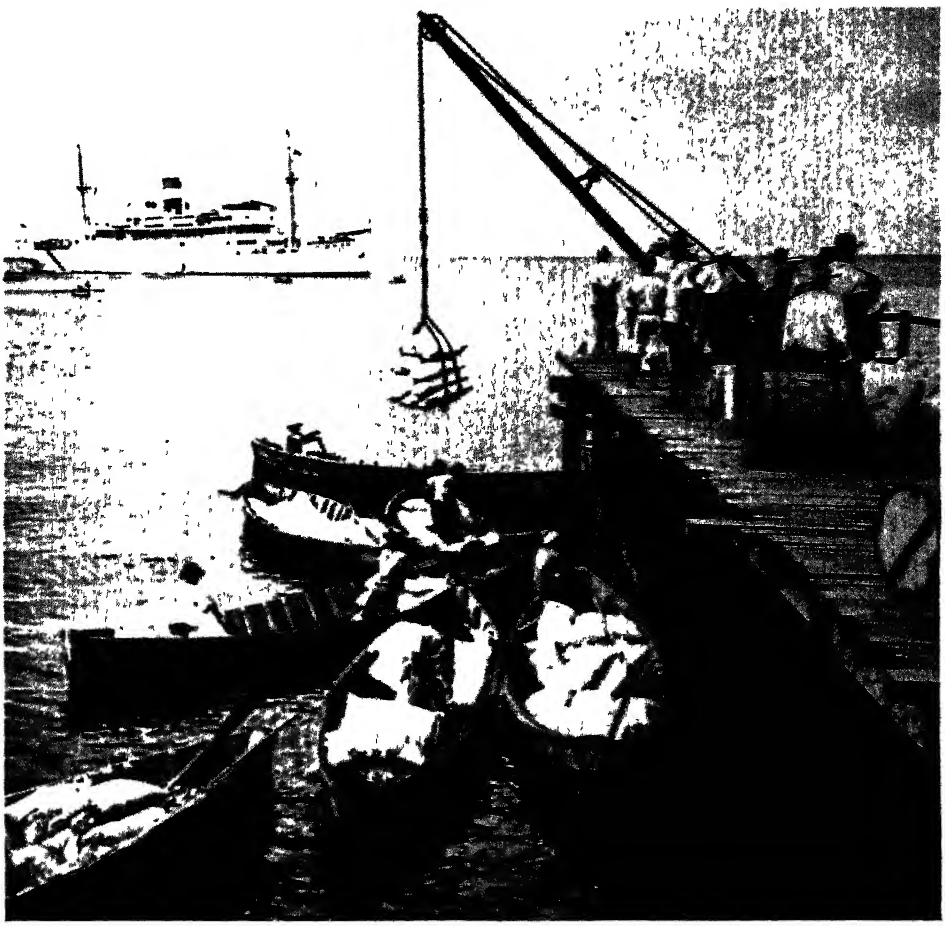
SINCE DOMINICA HAS NO GOOD HARBOR, SHIPS HAVE TO ANCHOR OFFSHORE. IN THE RIGHT BACKGROUND IS THE SOUTHWESTERN TIP OF THE ISLAND—SCOTS HEAD—ONCE HEAVILY FORTIFIED.

slopes of Morne Bruce, from whose summit, reached by a zigzag path, can be seen all of Roseau from the tiny wharves to the spread of the gardens several hundred feet below. What past sights the Morne must have seen, for like her giant sister peaks towering in the background she overlooks a part of the Caribbean that has always been glamorous, having borne successively on her heaving swells Carib canoes, Spanish galleons, French and British frigates. Today, even in wartime, the tranquility of this, Roseau's guardian peak, is reflected on the western crest by the shrine and cross overlooking the town, on the eastern crest by an old mango tree which hangs over one of Dominica's most accessible and breath-taking panoramas—a view of the mountain-bordered Roseau River Valley clambering far below, yet ever upward to the base of the Lake Mountain and the rising point of the sun.

Few of Dominica's highways extend for more than a dozen miles, although the Portsmouth-Marigot "turnpike" has the unbelievable length of twenty-two miles! What Dominica's roads lack in length and width

they make up in startling views and sudden grades and curves that try to break the vehicle in two. The wonder is not the scarcity of roads but that the government authorities were able to construct any. Take a range of mountains rugged and precipitous; dip them into the Caribbean so that 5.000 feet of their summits rise sheer from the sea; cloak them with verdure that only the rainy tropics can produce; then try to cut roads through—roads that will stick to the sides of the deep ravines and valleys and that will not be obliterated at the first daily deluge. Here in a nutshell are the difficulties of Dominica road-building!

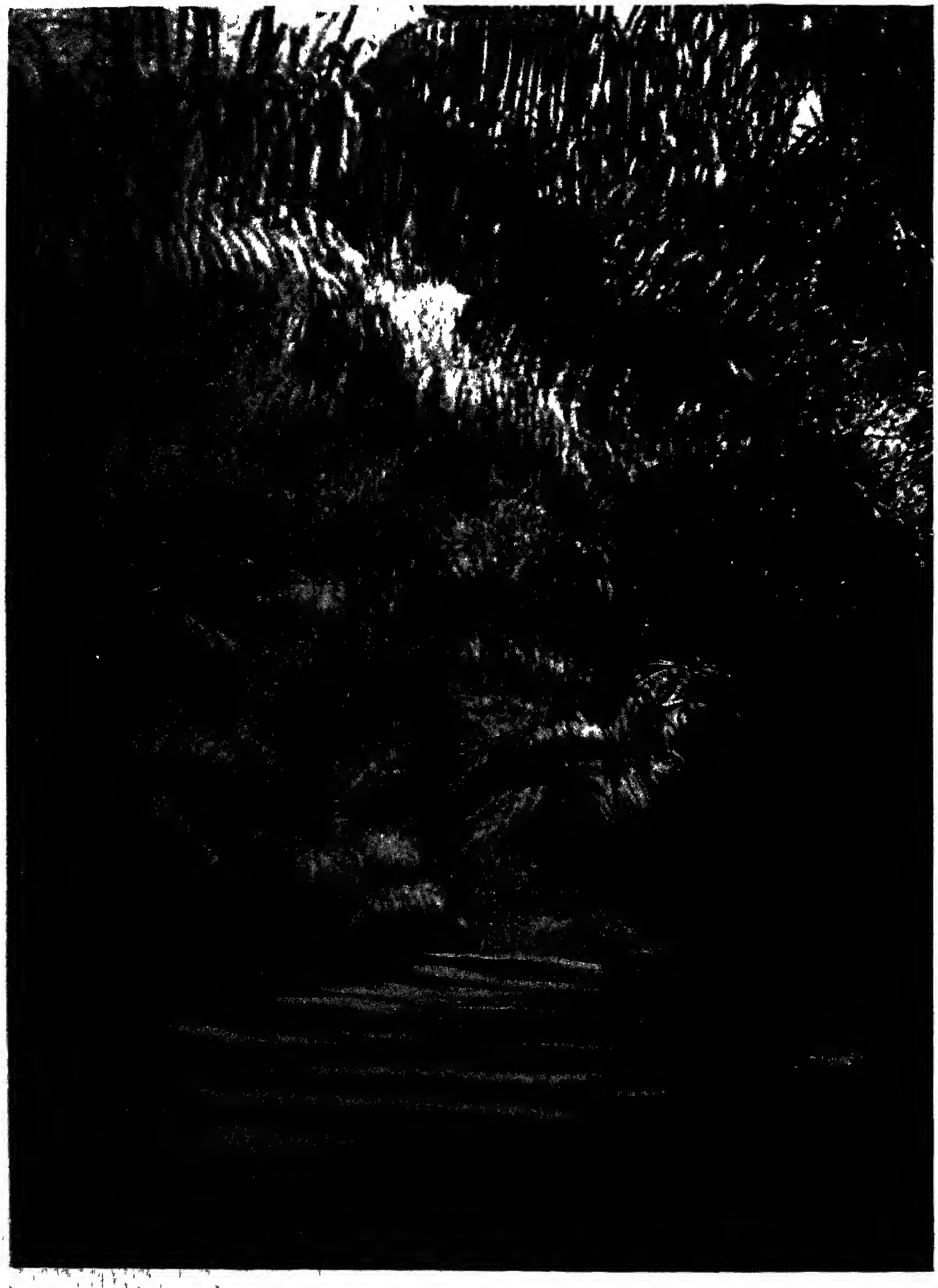
Walsh was a good driver and the scenery on the way to Bellevue was fascinating; first came the shore road with its border of coconut palms making alluring the seaside hovels, picturesque with their gaping fauna of natives, chickens, and mongrel dogs and sheltered by the ever-present breadfruit or mango tree. Like leaf-cutting ants in one continuous line, the road-pursuing humanity presented an ever-changing aspect; these by the sea are fisherfolk—one would readily know it; boats, half rowboat, half canoe, are drawn up everywhere on the beach or are stored beneath palm-thatched shelters; in the shade of this shanty is a weaver of fishpots; just beyond, around that inviting curve, the knell is being sounded for the sale of a pile of still-brilliant blue parrotfish, the purchasers called by the low moan of the sea, emitted by a conch horn. But the road cannot continue forever to the south for Pointe



UNLOADING FLOUR NEAR THE ROSEAU ANCHORAGE

SUCH COMMODITIES ARE IMPORTED FROM CANADA BUT, BECAUSE OF THE WAR, IMPORTS HAVE PRACTICALLY STOPPED. THE HOGSHEADS ON THE RIGHT CONTAIN MANGOES PREPARED FOR EXPORT.

Michel and Scots Head are just beyond, and then nothing but sea. Sure enough, Walsh turns east abruptly at Loubière—the scene of a desperate attack (1805) on the island by Napoleon's General La Grange—and the road pitches steeply upward. The scenery rapidly changes; there are fewer tiny houses, but here and there a larger estate house appears among the foliage. Cocoa trees now border the roadway, banana plots are everywhere, and still there are the wayfarers descending now in waning numbers from no



A LANE OF WINE PALMS IN THE BOTANIC GARDEN

THE ROSEAU GARDENS, AS WELL KEPT AS AN ENGLISH PARK, HAVE ONE OF THE FINEST PALM COLLECTIONS IN THIS HEMISPHERE. THE ASSOCIATED AGRICULTURAL STATION IS AN AID TO LOCAL PLANTERS.

one knows where, down, down, down into the town carrying a cross-section of the island's produce. Take a look at the various loaded heads. Most common of Dominica's coiffeurs is a bunch of green bananas probably bound for the distant Canadian markets. Clarice, our maid, tells us that a woman will probably get a shilling for growing the bunch, carrying it a dozen miles, and depositing it at the island's cooperative banana exchange.

Bananas are not the only story though, for mangoes, like oxhearts, dasheens, and breadfruits, are piled high on the heads of these human truckhorses. Now a walking haystack approaches, and only when near do we find the beast of burden to be an old woman with maidenly carriage.

For six long miles we had been thrusting the engine of the car into the sky; every one of the many turns was a possible jumping-off spot to a green, stream-gouged, verdant chasm, hundreds of feet below. What civilization had existed had long since disappeared, and the plantain-covered slopes, unbelievably steep for cultivation, were being claimed by a vegetation born of nature. Tree ferns, as only Dominica can produce them, predominated, arching over the roadway and filtering motes of sunlight through a filigree of fronds. There are five kinds of tree ferns on this little island plus about 200 other fern species, which vary from thirty-foot arborescent giants to tiny filmy epiphytes scarcely a quarter of an inch high. Real variety when one considers that so-called ferny New England can boast of a mere sixty odd species!

Near Bellevue we found heaven in a castle in the air, a modest one-story dwelling tied to the ground by a ten-foot poinsettia hedge. The simplicity of the walls of the three rooms well set off the landscape murals that were the mountain vistas framed by the screenless windows (no insects). There were no electric lights, fans, or refrigerators, no hot or cold running water, no tennis courts or swimming pools—none of those things that make life so like a yardstick.

The sole boundaries of this kingdom were mountains; behind our cloud-swept castle towered Morne Anglais, supported it seemed by two lofty coconut palms, sentinels at our back door. Beyond our front steps two other peaks rose, one to the north and one to the south, the shoulders of the latter, Morne Plat Pays, slipping into the Caribbean only, it seemed, to rise again thirty miles due south in the hazy mirage that was catastrophic Mount Pelée on distant Martinique. Close at hand, for our work, was the untrammeled rain forest; a bare hundred feet from the back door and in another direction were the

ALL LOADS ARE "HEADED"
MAN ON THE LEFT IS THE ROSEAU-ROSALIE POSTMAN WHOSE ROUTE CARRIES HIM FIFTEEN HARD MILES ACROSS THE ISLAND'S RUGGED BACKBONE.

cultivated areas which represented our vegetable supply.

Every kingdom must have its subjects, and Lisdara was no exception. Most important was Clarice who managed our day for us; it was she who woke us with the birds; she was the cook as well as our maid and lady-in-waiting, and besides all this she fulfilled the position of technical assistant, interpreter, and publicity girl. Could we have asked for more, especially at five shillings a week? "Master," she would say, "your plants are about cooked," and the Master, whose plants could only be dried by means of artificial

THE BOTANIC GARDENS
MORNE BRUCE AND SHRINE IN THE BACKGROUND.

heat, would run to the improvised rain-barrel heater in the kitchen to replace the "cooked" plants, in press, with some fresh specimens.

On an island not noted for the excellence of its communication system, it was little short of miraculous to find that knowledge of our coming had long preceded us. Our equipment had scarcely been unloaded when a babble of native voices, conversing in the universal creole patois that bespeaks a former French affiliation, descended upon us, and Clarice burst in with, "Men are without to sell you things!" Dominica venders; how they ever knew we were scientists still baffles me, but here they were on the front steps. There were old men and young men, boys and even children, each with his little contribution for sale—hopping *crapaux* (frogs), a *tête chien* (Dominica boa), geckos and centipedes, blue crabs and black crabs—everything except plants! It did not take us long to venture into the green of the forest beyond the house and onto a trail which dipped either down or up in one of the only two possible directions, through forests that continually dripped, for at this altitude we were really in cloudland. An umbrella was a standard encumbrance in the rainy season; not for ourselves but for the camera, since one could never be sure that, with camera all set up on tripod, the elements would not open up and drench the equipment. In Dominica there is seldom a steady downpour but rather a series of short cloudbursts from the puffy cumulus clouds that are pushed along by the moist east-west trade-winds. Their shadow paths are marked by sheets of water which, starting upon the distant forested slopes with a low moan, rapidly increase to a roar in the nearby trees only to prance upon the corrugations of the galvanized roof with a flailing power that drowns out sounds beneath. It is fun to predict the weather in the mountains. A good estimate is that on fair days it rains "cats and dogs" about once an hour, whereas on rainy days a deluge can be expected about once every fifteen minutes. No wonder rainfall can be measured in feet, for the annual precipitation at 2,000 feet altitude is well over 200 inches, while at 4,000 feet rainfall is enormous, probably reaching 400 inches a year. Such incessant rain certainly is a boom to plant life. Our pet cotlette tree in the front of the house proved this well, for all over its limbs, in Dominica luxuriance, sat scores of guest plants—clambering ferns, brilliant bromelias, and tiny orchids. Several hours of collecting from just this one tree gave hint of the riotous production of the tropics.

To make good botanical specimens tropic plant collections require artificial heat, lack of which in a supersaturated atmosphere means attack by mold and mildew, chief enemies of the botanic collector. We had filched one of the galvanized rain barrels used to collect our water supply. In the bottom was placed one of those little charcoal stoves, common on the island, and on

A LOCAL MOUNTAIN FROG
FROGS' LEGS, CALLED "MOUNTAIN CHICKEN," ARE THE TENDEREST DELICACY ON THIS ISLAND.

which in some unbelievable fashion Clarice would prepare everything that went into a full-course dinner. Across the top of the barrel were placed the plant presses; thus arranged, the heat rising through the corrugated channels of the press would in a day thoroughly dry all succulent specimens.

Work was interrupted only by meals, pleasantly varied so as to be exemplary of West Indian offerings. Our menu included "mountain chicken," the tender legs of a feet served with cucumbers and condiments. As side dishes one could expect the ubiquitous banana, prepared often as a vegetable and served in a multitude of delightful forms running from baked plantain to a fried form which reminded us of candied yams. Fruits were from Heaven, just out of the window; the juicy sweetness of mangoes or fresh pineapples, the pulpy whiteness of a sugar-apple, or best of all the indescribable flavor of a garnet mangosteen; we tried them all.

TROPICAL PLANT COLLECTIONS REQUIRE ARTIFICIAL HEAT
AN OLD OIL DRUM, CHARCOAL FIRE AND NATIVE LEAN-TO ARE AIDS TO THE DOMINICAN BOTANIST.

mountain frog called *crapaud,* in patios. These were caught by means of flares at night, and twelve cents' worth supplied a delicious meal. Another meat was smoked agouti, greatest delicacy the island can offer, with a wild flavor nearest to ham and prepared from the island's piglike native mammal (*Dasyprocta*); crab-backs, crab-meat served in the shell of the omnipresent *cirique* land crab; *tritri,* slender minnowlike fish which in season ascend the rivers in such numbers as even to fill the water supply and startle the stranger by swimming around in his bath; souse, the Dominica Sunday breakfast dish made of long-boiled pickled pig's

In 1791 Thomas Atwood, writing a history of Dominica, noted that two-thirds of the island was covered by forest. This forest area still remains intact for, although the companion Antillean islands, because of their comparative lowness and accessibility, have lost much of their original stands, Dominica alone has retained them. Her loftiness has been at once her savior and the millstone around her neck, for, although her beauty has never aged, she has had to sacrifice riches for it since economically speaking Dominica is poor. Her soil is rich, but the difficulty is to cultivate soil which is situated on what are for all intents and purposes

ninety degree slopes and which when cleared of forest become sterile and eroded away by landslides caused by incessant rain.

It is amazing, under such adverse conditions, that fruit culture should prosper; and yet it does, with the aid of empire tariffs Every other Saturday when one of the shimmering white mail ships (now in wartime camouflage) announces itself with a clatter of anchor chain, there are at Roseau upward of ten to twenty thousand stems of bright-green bananas lying in their packing of coconut rubble awaiting shipment to Canada's northern markets This fortnightly shipment represents chiefly the cumulative additions of small native gardens. A Dominica peasant may be "as poor as Job's turkey" but he usually owns land, for land is available to almost anyone who will keep it cleared and cultivated; furthermore, he never need worry about taxes, for this is one of the places in the world which knows nothing of land taxes! For the lover of the outdoors this is the place to retire, on an island where forested crown lands are still available at $2.50 an acre. Since the exposed coastal soils are the poorest and least productive, most peasant holdings are situated inland far from the seaside villages, and so we may add that Dominica's agricultural peasantry is a race of commuters, daily walking lengthy distances over rugged terrain from their tiny homes in the villages to their gardens hanging onto the precipitous sides of volcanic peaks. No wonder the toiler of the soil remains poor! The best part of his day is a tedious hike to and from his tiny mountain plot, and as one native so aptly put it, he has to rest the intervening period in order to gain enough strength to walk home again! Perhaps it is this strength that the average wayfarer has in mind when he tries to get some quick energy by thieving some of his neighbor's produce from the garden by the road. To guard against just such plundering is the purpose of many of the inaccessible little cultivated plots that the traveler sees far above the trails; and knowing this, one can understand the little signs in the Roseau market place that read "Licensed to sell protected produce."

But although bananas help to bring what little wherewithal this tiny isle possesses, Dominica long ago associated itself with limes and lime production. So well at first did the cultivation of this fruit progress that at the beginning of the first World War the center of the world's lime industry was focused on the coastal plantations of this Windward isle. Green limes, pickled limes, raw juice, citrate of lime, essential oil of limes, and Otto of limes—all found their way to the United States and to parts of the British Empire. It is said even that the English term "limy" originated here. It is true that Dominica juice was issued for many years to the British Navy on account of its antiscorbutic properties, and only the transfer of affection for economy's sake from empire-grown limes to Sicilian lemons succeeded in again causing the strangulation of a prospering industry. New citrus diseases have not hindered its decline, nor have the ravages of periodic hurricanes, which, born in the Atlantic east of the island, increase sufficiently in fury to roll up heavy devastation in the orchards.

*(To be concluded)*

# WOOD COMES OF AGE

By F. J. CHAMPION

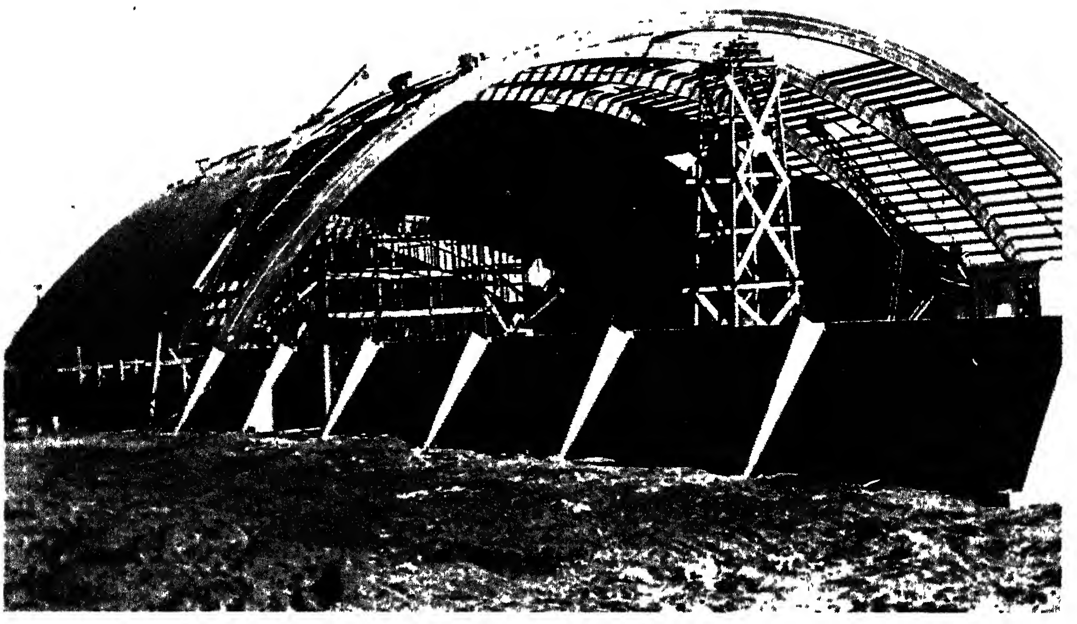
IN the inevitable postwar struggle of raw materials for commodity markets, wood will meet intensified competition from metals, plastics, ceramics, glass, and other products. But wood, like competing materials, will be available in improved forms—for the centuries of empiricism in the use of wood are drawing to a close and at last wood is technologically coming of age. War has tremendously accelerated the process. Even now a number of new products of the forest are already serving the war effort, and the ironing out of technical shortcomings and production difficulties of other forest products is being so stimulated that developmental work ordinarily requiring years is being accomplished in months.

Some of the new wood derivatives and modified wood products are so altered as not to be recognized as wood; others look like wood but magnify wood's major virtues and add to its versatility. Notable among the improvements in properties is the reduction of swelling and shrinking characteristics of normal wood that have often limited its serviceability.

Some of the newer wood products, already established in the service of war production and now past the period of development and trial, are in use in the construction field. Moisture-resistant plywood is notable in this field. The development of ordinary plywood, a product that dates back hundreds of years, made wood available in large sheets having properties more nearly uniform in all directions than normal wood, but it was only when weather-resistant glues were developed that this material assumed major importance

WOODEN FOOT BRIDGE AT MADISON, WISCONSIN

THE FIRST LAMINATED ARCH BRIDGE OVER U. S WATER IS SUPPORTED ON TWO GLUED LAMINATED ARCHES.



BUTTRESSED GLUED LAMINATED WOOD ARCHES FOR FIELD HOUSE
GUSTAVUS ADOLPHUS COLLEGE. THESE PROVIDE WIDE SPANS WITH UNOBSTRUCTED FLOOR AND OVERHEAD SPACE.

as a material for outdoor uses, especially for housing and for industrial and farm structures.

A considerable portion of the effort toward mass production of housing—conventional, prefabricated, and demountable—achieved significant headway only with the development of water-resistant phenolic-resin glues for structural plywood.

One of the earliest successful efforts to design a practical factory-fabricated system of building units for house construction based on plywood took place at the Forest Products Laboratory of the Forest Service, U. S. Department of Agriculture. Using the monocoque or stressed-skin principle common in aircraft design, plywood-covered building units planned to a 4-foot modulus, complete with insulation, moisture barriers, wiring, etc., were designed, and several model houses were erected on the Forest Products Laboratory grounds at Madison, Wisconsin, and are still giving satisfactory service after eight years of testing, observation, and occupancy.

The plywood covering of all the wall, floor, roof, window, and door units was glued, rather than nailed, to a light structural framework. One model house, when it was demolished to make way for another structure, showed ample resistance to wracking tests not likely to be encountered in anything short of a hurricane.

The stressed skin principle implies that, unlike conventional frame walls which consist of a heavy framework on which coverings are suspended as dead loads, the stressed skin panels divide the weight of the structure between the frame members and the glued-on plywood, hence the light framework used and relatively thin exterior walls (3 inches), and the ease and speed with which the units can be erected.

The Forest Products Laboratory prefabri-

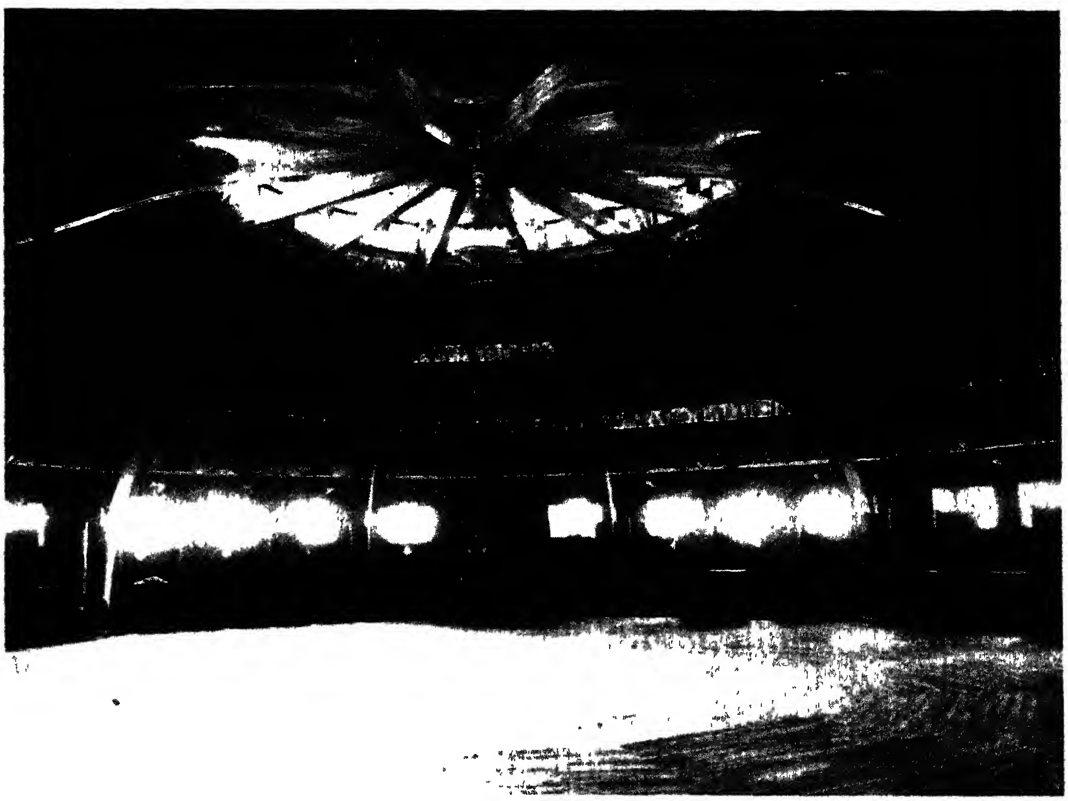
cation system, with modifications suggested by the experience of various fabricators and erectors, has been widely adopted and its influence is seen in the thousands of prefabricated plywood units that now shelter workers in war-crowded communities.

Heavy timber construction has made two important advances in recent years—modern connectors for improving timber joint strength and glued laminated arches—both items coming into considerable use just in time to help build many war structures, from shipways to camp recreation centers.

The weakest links in any conventional timber construction obviously are the joints, where loads are passed from one wooden member to another. Because of the relatively small cross sections of the steel bolts used, these transmitted loads are applied as shearing forces on areas of an inch (or less) of wood. Modern connectors are iron, steel, or even wooden rings, plates, or dowels inserted between timbers and surrounding the bolts to bring greater areas of wood into bearing and consequently to greatly increase the over-all strength of an entire timber structure.

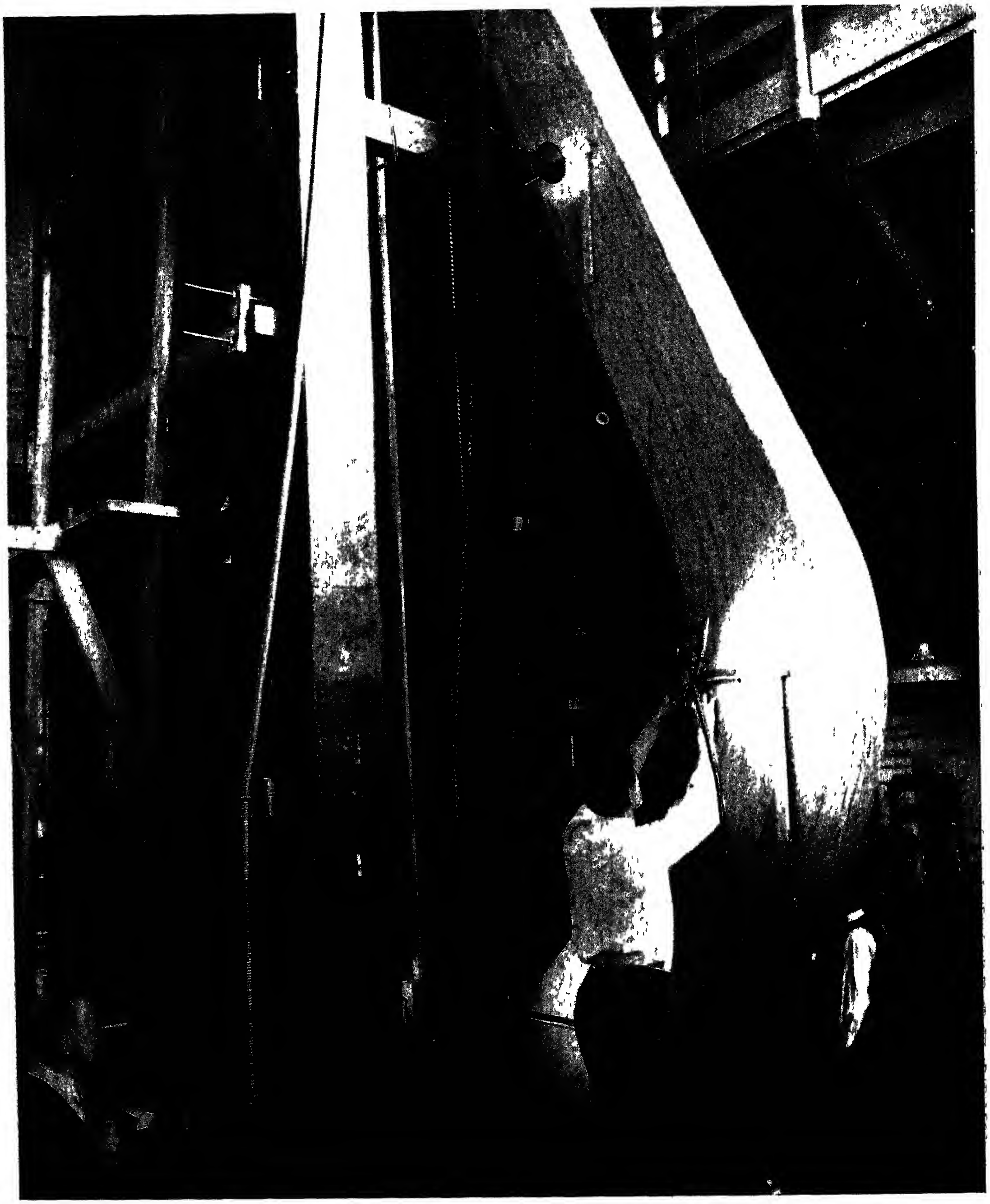
To illustrate the effect of the metal connectors, wood radio towers, formerly limited to a height of about 100 feet because of the limitations of joint strength, can now be erected to a height of 300 to 400 feet The use of connectors has been estimated to have saved 400,000 tons of steel in 1942, beside assuring joints 4 to 5 times as strong as anything possible with bolts alone. In many wood shipways, factories, warehouses, railroad bridges, and similar structures, connector-built joints are the literal sinews of war.

Other limitations of wood in the structural field have been surmounted by the engineering of large glued wood arches. Wood structural members are no longer limited by the practical size limits of timber coming from the mills, nor limited in shape by the



VERSATILITY OF THE GLUED LAMINATED WOOD ARCH

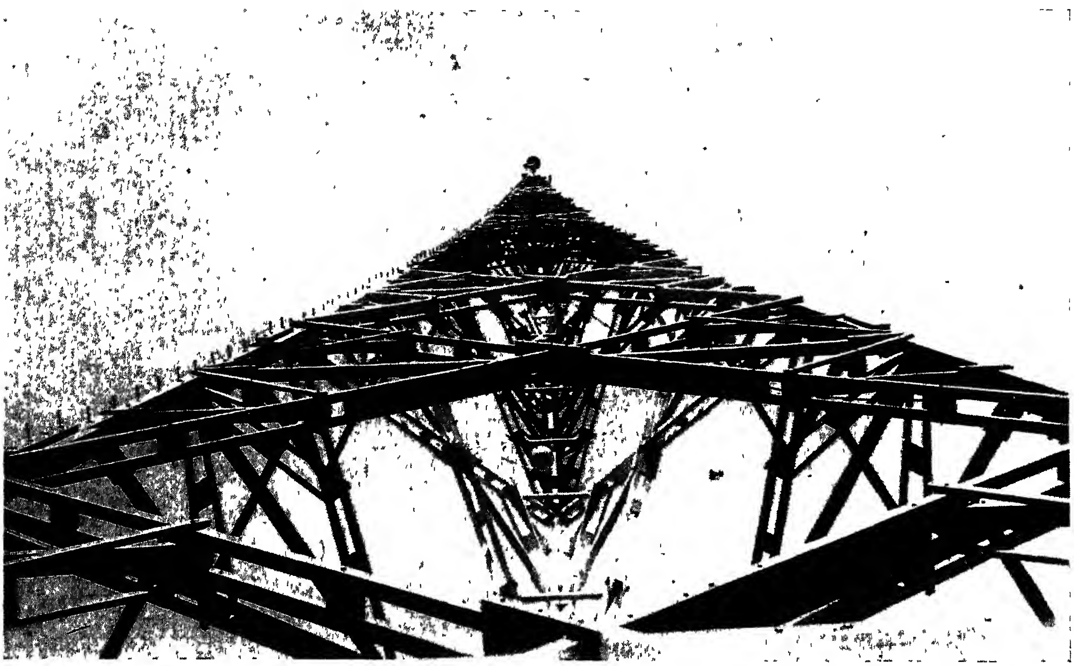
ILLUSTRATED BY THE DESIGN OF THE ROOF OF THIS NIGHT CLUB WITH ITS NEARLY SPHERICAL CONTOURS.



A FULL SIZED GLUED LAMINATED ARCH
BEING TESTED IN THE MILLION-POUND TESTING MACHINE AT THE UNITED STATES FOREST PRODUCTS LABORATORY.

fact that tree boles bear little resemblance to trusses or arches.

The use of glued arches in this country received real impetus when the Forest Products Laboratory undertook basic investigations and tests and published data that made it possible for American construction men to design wood arches on sound engineering principles. Arches in use today vary from flat ellipsoid types with a clear span of over



TIMBER-JOINTED, 326-FOOT WOOD TOWER OF WRVA, RICHMOND, VIRGINIA

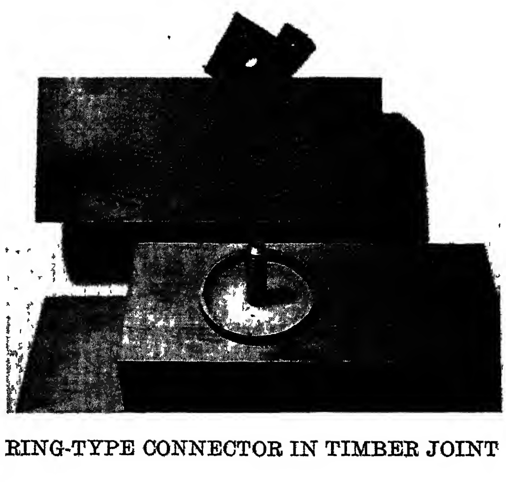
150 feet to small Gothic type arches that have been used to build small churches having surprising architectural appeal, resulting from using the arches as a conspicuous feature of the interior.

Laminated arches are fabricated to order at the factory, shaped to the function which they are to perform, with thick sections where stresses are concentrated; curved and tapered to follow side wall and roof slopes and to conform to the varying concentrations of load. Glued arches are classified as slow burning and require no special sheathing to guard against sudden failure in case of fire.

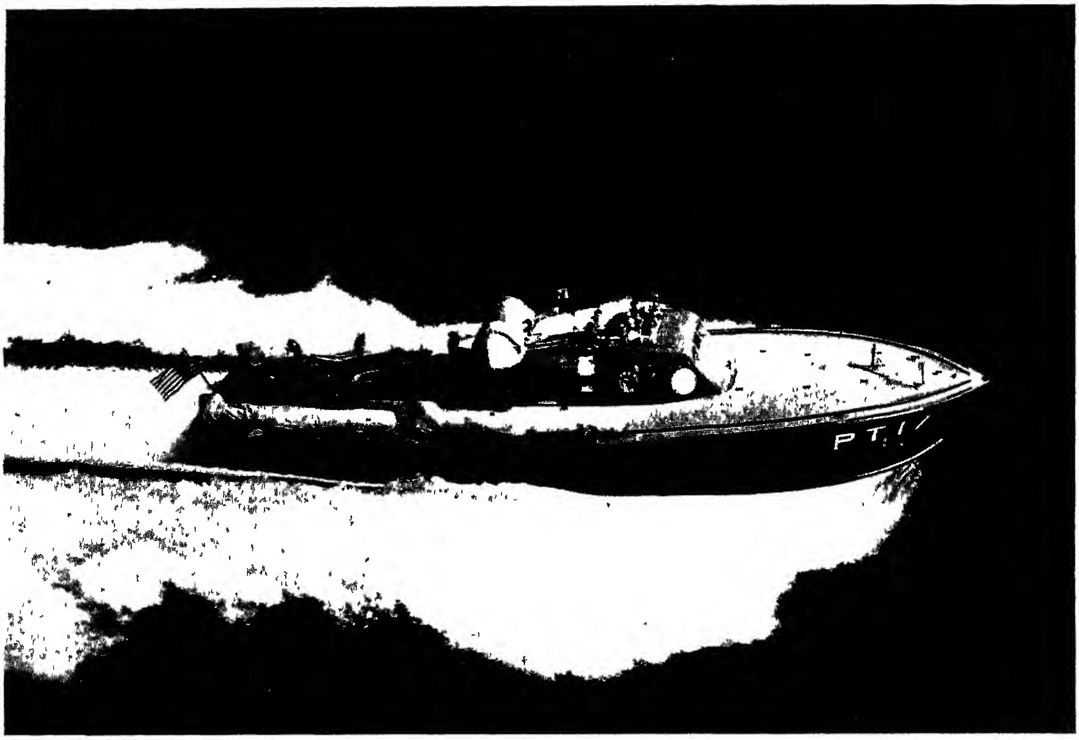
Hundreds of tons of steel have been saved during the period of preparation for war and since Pearl Harbor by the employment of glued laminated wood arches in factories, hangars, drill halls, and similar structures. Seagoing counterparts of the glued wood arch are the glued laminated ship keels and frames now going in hundreds of small naval craft to take the place of hewn timbers of large cross section.

The demand for moisture-resistant plywood construction for both airplanes and naval craft has led to new refinements in the fabrication of plywood that will inevitably be of permanent service in consumer goods. Perhaps the most striking development in this field has to do with the molding of weatherproof resin-bonded plywood to the curved shapes associated with marine architecture and the requirements of aerodynamics.

Where ordinary die molding will not suffice to produce parts having pronounced curvature or curvature in two planes, fluid pressure molding or so-called bag molding is resorted to. In this procedure strips of thin



RING-TYPE CONNECTOR IN TIMBER JOINT




A PT BOAT WITH HULL OF PLYWOOD

plywood coated with glue are laid up on the contours of convex or concave molds, and held in intimate contact with the mold by inflating or deflating a pressure bag or blanket against them until the glue has been set by heat supplied to the mold or bag.

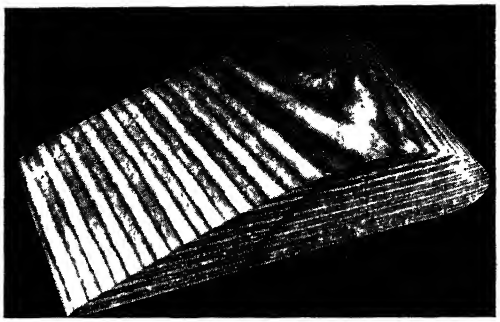
The principle can be illustrated by laying strips of paper over the contours of a teacup, covering the whole with a rubber toy balloon and exhausting the air until atmospheric pressure molds the rubber and strips to the contours of the cup; or by lining the inside of the cup (a concave mold) with the paper strips and inflating the toy balloon inside the cup.

Half fuselages, complete with bonded structural members, have been produced by bag molding, as have also small boat hulls, and many small aircraft units such as nose and tail cones, and air ducts and scoops. Complete planes made up of molded units have been built and successfully flown.

The most recent group of new wood products includes "impreg," "compreg," "hydroxylin," "papreg," and "uralloy," and commercial products similar to these laboratory creations. These materials, illustrating the scientific approach to modification of wood properties, show the most striking improvement over the usual properties of wood This can be credited to the fact that all owe their origin to chemical or physical modification of the basic cellulose-lignin units of minute wood structure. All of these products base their invention on the knowledge that lignin, the cementing substance which surrounds and binds the cellulose fibers, can be plasticized by chemical treatment and made to flow, and on the fact that the physical behavior of wood can be made more stable by bonding added chemical groups to the cellulose of the fiber wall and the interfiber lignin. The result of proper application of these facts is to fortify wood against its primary shortcomings, pronounced moisture fluctuations and resulting swelling and shrinking, susceptibility to fungus organisms, and to fire, and in some instances deficiency in strength properties.

*Impreg* is resin-treated laminated wood with a high degree of moisture resistance (hence low swelling and shrinking) and im-

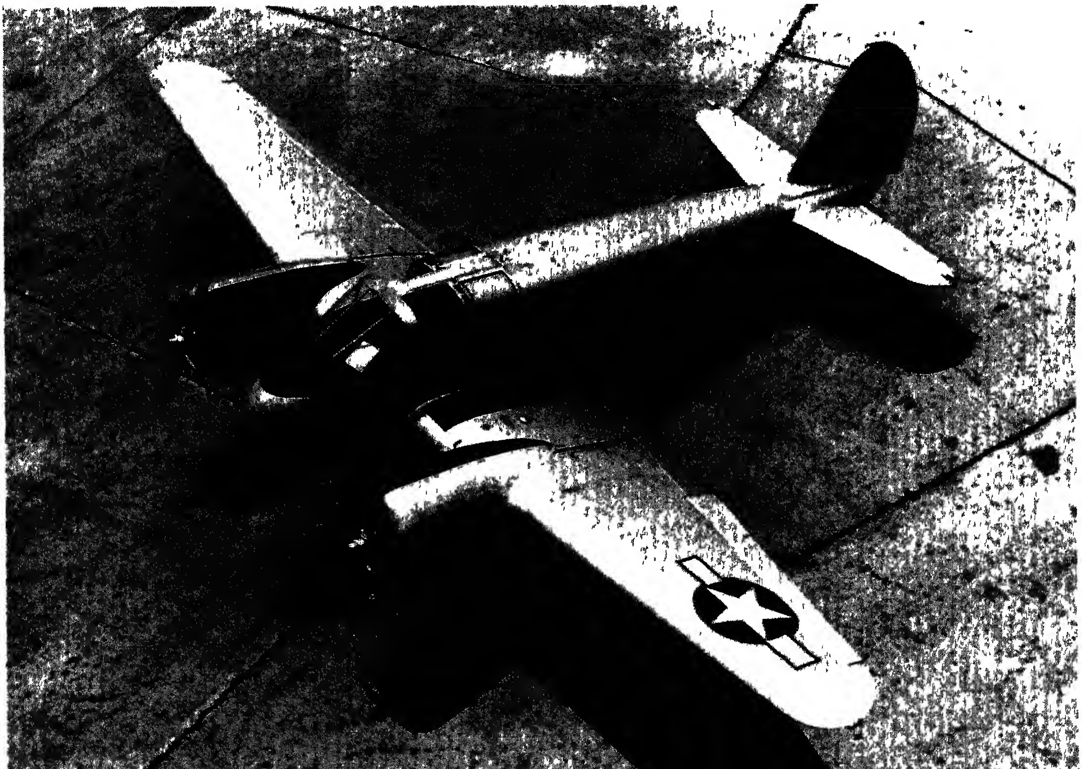
proved resistance to decay, fire, and to surface checking and weathering. In the manufacture of this product sheets of veneer are impregnated with a water solution of resin-forming chemicals, then dried and cured to cause the resin to polymerize or set within the wood The treated veneers are laid up and hot-press bonded with resin glues to form a superior plywood. Success of the resin-impregnation treatment is dependent on selection of a resin and impregnation method that brings about not only introduction of resin to the hollow interior or lumen of the fiber but also a chemical bonding of the resins to the cellulose fiber wall itself. Thus the fiber is altered chemically and is no longer free to exercise fully its affinity for water and to swell as moisture



SECTION THROUGH COMPREG PROPELLER

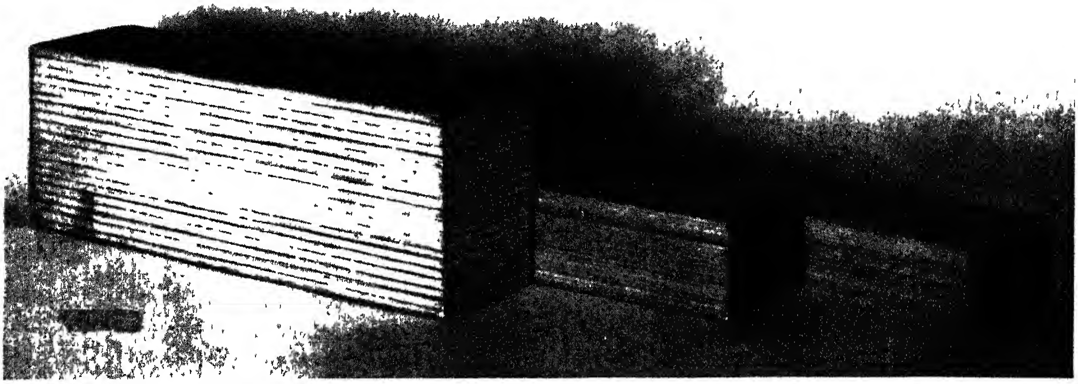
is absorbed and to shrink when moisture is given up.

Impreg resembles natural wood unless dyes are added to the impregnating resins. When light-fast dyes are found for impreg



BEECHCRAFT TRAINER SHOWING WOOD SUBSTITUTION

MAXIMUM SUBSTITUTION OF WOOD AND PLYWOOD FOR METAL HAS BEEN MADE IN BUILDING THESE TRAINERS.



UNCOMPRESSED LAMINAE AND TWO GRADES OF COMPREG

UNCOMPRESSED RESIN-TREATED LAMINAE AND COMPREG PRESSED AT 250 AND 1,000 POUNDS PER SQUARE INCH.

it will be possible to produce this durable material in colors completely permeating at least the outer thickness of veneer, thus obviating the need of any other finish

*Compreg* in the making receives the same initial treatment as impreg but the simple curing treatment of the resin-treated sheets is replaced by hot pressing at varying pressures, depending on the properties desired. As the resin has a plasticizing effect on the lignin, the resin-treated wood compresses much more readily than untreated wood at the same pressures so that under moderate pressure the stack of veneer is compressed to a half or a third of its original thickness, thus acquiring added density. At the same time the resin diffused through the veneer sheets bonds them into a solid panel with considerably increased homogeneity. The resulting product has resistance to moisture, shrinking and swelling, fire, and decay equal to or better than impreg, but its density has been doubled and it has acquired a surface hardness of 60 to 90 as compared with that of plate glass at 100. The compreg takes a high gloss from the platens of the press, but the outstanding feature of the finish is that in effect it permeates the whole panel. Scratches on the surface can be removed by sanding and buffing without other treatment and cut surfaces can be brought to a high finish by similar treatment.

Compreg can be produced in thin sheets, amenable to molding techniques, or in thick blocks suitable for such purposes as the carving of propellers. As a matter of fact propellers of compreg are in production both by carving and by the molding from pretailored assemblies of resin-bonded and impregnated plies. Other aircraft parts, such as radio antennae masts, chart cases, and bucket seats, are in production.

The most immediate allure of compreg to the layman is its high gloss and its appeal to the sense of touch. It is hard, highly polished, heavy (specific gravity 1.0 to 1.3), and usually richer and darker in color than the wood from which it was laminated. Due to the concentrations of resin between plies, laminations running out on curved surfaces give an attractive synthetic "grain," independent of the actual grain of the wood. Shrinking and swelling of compreg are negligible, actual submersion tests of 50 days showing a swelling of only 3.6 percent. As compreg resists water, alcohol, and mild acids, and is not permanently spotted by these materials, its suitability for table and bar tops, chemical benches and similar uses is apparent.

It should perhaps be pointed out that compreg is a specialty product, not too costly for military aircraft, but not yet within the price range of common structural materials. On the other hand, especially if quantity production results in lowered costs, it seems reasonable to expect that in the postwar period compreg will come into its own for fine furniture items, architectural details, and similar uses where attractive appearance, high durability, strength, and easy maintenance are essential.

Combinations in which compreg faces of high durability are formed on cores of impreg or untreated wood in a single operation suggest one way in which both weight and cost can be reduced in sheet or molded materials having most of the advantages of full compreg.

*Hydroxylin* is wood's own entry in the field of low-cost, general purpose plastics. Made in two forms—molding powder and laminating sheets—both from hardwood wastes, it is classed as a low-cost plastic and has certain desirable properties, notably high acid resistance. Its future should be influenced by its performance in war material and by production experience gained by war contractors who will apparently be the first to use hydroxylin in quantity.

Made in only one color—jet, glossy, black—hydroxylin is in effect a lignin plastic with a cellulose filler In making the molding powder, sawdust or wood chips are hydrolyzed with a weak acid or aniline to convert part of the cellulose in the wood to sugars which are removed by washing. This operation increases the percentage of lignin in the resulting "mash," which is dried and milled to a fine powder and to which a small amount of any one of a number of plasticizing agents may be added to lower the flow point of the lignin. The cellulose remaining in the molding mixture acts as a filler, just as wood flour does in many common phenolic molding materials, to increase the strength. Water

HYDROXYLIN MOLDING POWDER, EXPERIMENTAL MOLD, TEST MOLDS OF AN ASH TRAY

resistance of the mixture is dependent on the amount of lignin present. The cellulose derived sugars referred to as a by-product of the hydrolysis process could be broken down by fermentation to produce ethyl alcohol in operations large enough to guarantee continuous production.

Hydroxylin is relatively hard and strong, has high electrical resistance, and can be cut with machine tools like metal. It is relatively light in weight (specific gravity 1 40) and bonds well to metals such as brass, bronze, and aluminum. The hydrolyzed wood sheet can be laminated under heat and pressure to form, under double curvature if desired, a material that has promise for many uses.

Efforts of one war contractor to get into production with a hydroxylin battery box for military airplanes appear to be nearing success. In this case the wood-derived material will replace hard rubber (now out of the picture because of war scarcity) with a significant saving in weight because of the greater strength per unit weight of the hydroxylin.

*Papreg,* one of the most recently developed products of wood conversion to receive attention, is a high-tensile-strength, plastic-like paper laminate which is being tested for the production of stressed parts in aircraft as a substitute for light metals. Resin-impregnated paper laminates are by no means new, but papreg is unique in that among such laminates its strength properties are such as to merit serious attention, notably on the part of aircraft designers, for objects taking considerable stress. The significant technical

PAPREG: LAMINATED, TREATED PAPER

development of papreg is being carried out by the Forest Products Laboratory with a view to its potentialities as a substitute for aluminum in military aircraft, hence detailed information on its production and on its properties remain in the realm of classified restricted information, available only to manufacturers and processors authorized by Government war agencies to receive such information to aid the national war effort.

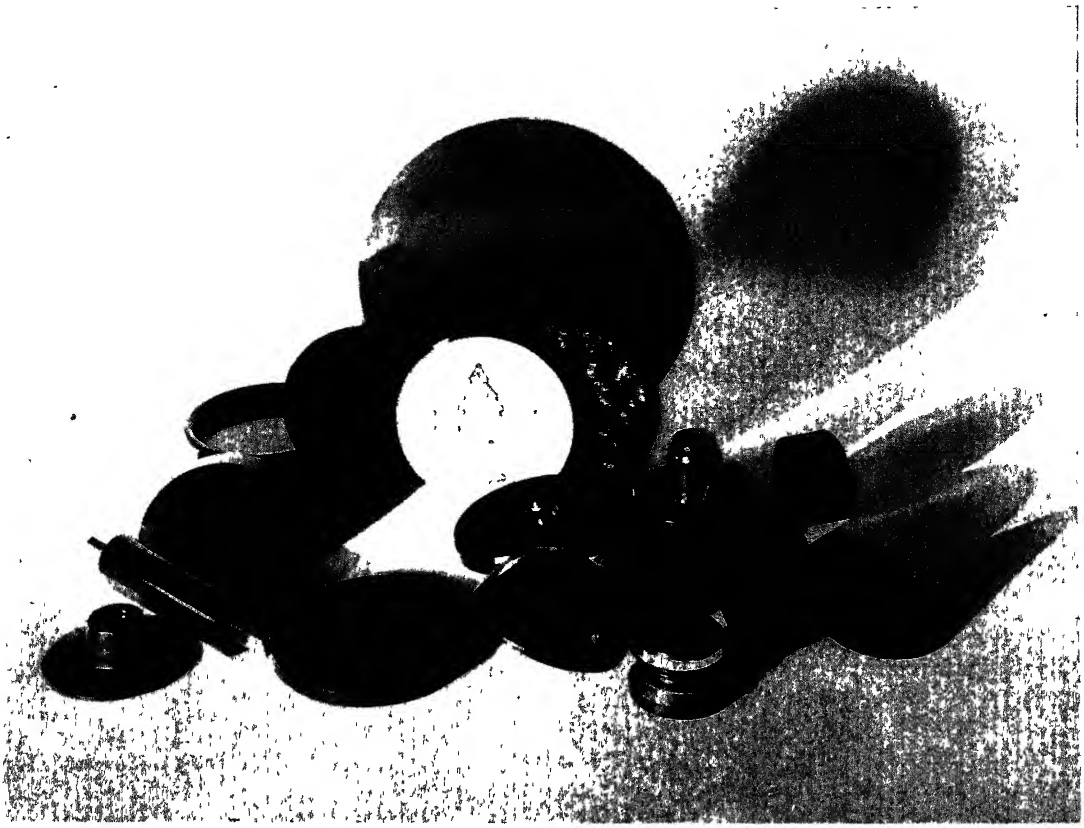
The following quotation from an official release sums up the information that is available to the public:

> An improved paper-base plastic equaling aluminum in tensile strength on a weight basis has been developed and is being produced experimentally in the form of aircraft parts, including wing ribs, wing tip skins, and control surfaces.
>
> Experimental data thus far obtained in laboratory tests indicate that the product has twice as great tensile strength as any paper laminated plastic hitherto produced; that it can be molded to desired shapes at temperatures and pressures and on equipment now used for making plywood; that it is resistant to moisture and remains extremely stable at both high and low temperatures, and that it is more resistant to scratching and denting than aluminum. The plastic has a smooth surface, eliminating the necessity for special finishes and coatings.
>
> Tests also indicate that it does not splinter, tear, nor flower out when pierced by bullets.
>
> The properties of papreg, which can be varied to meet special needs, also give promise for use in water craft ranging from small boats to cargo vessels, and in the hulls of flying boats.

Papreg is another product of high durability, strength, and stability that has obvious possibilities for consumer goods, particularly since it might be given a variety of decorative treatments. At present, however, little thought has been given to consumer uses; its future in this field will be determined by economic competition of the raw materials after the war.

*Uralloy*—urea-plasticized wood—has not reached a stage of refinement as advanced as the other products described, but it is capable of modification in ways that should make it practical for many postwar uses. Essentially the process of making uralloy consists in soaking green wood in a solution of urea, drying it, heating it to about the boiling point of water, and shaping it or bending it at this temperature.

This type of processing results in a prod-



EXPERIMENTAL MOLDED OBJECTS OF HYDROXYLIN

uct which is thermoplastic, that is, capable of being returned to its original shape on reheating, but a thermosetting product can be made by adding a resin-forming chemical to the urea solution and altering the subsequent treatment The thermosetting type of uralloy retains its shape on reheating and has moisture resistance that is lacking in the thermoplastic form. Control of the thermosetting process can also be used to resinify the wood and produce simple hardening.

Initial experiments on uralloy were made with oak, which appears to be especially suited to the treatment. Other woods, however, have been made into various forms of uralloy with success.

In addition to the new products that have been mentioned there is an indication that it will be possible to make additional forms of moisture-stabilized wood without resort to full resin impregnation. It is also obvious that there are manifold possibilities of combining impreg, compreg, papreg, plywood, and untreated wood. Intriguing also is the prospect of surfacing light woods or other light filler substances with durable face plies to produce a variety of so-called "sandwich" materials. The success obtained with plywood-faced balsa in constructing the doughty British Mosquito bomber of daylight bombing fame will no doubt be the forerunner of a considerable line of "sandwich" combinations that will find their way into peacetime commodities.

Some new wood derivatives and new wood processing methods, not immediately applicable to war needs, lie dormant in chemists' notebooks. An example is the hydrogenation method for processing lignin, the binding constituent of wood that until recent years has been a good deal of a chemical mystery. By subjecting aqueous solutions of lignin from waste pulping liquor or other sources to hydrogen under pressure, a variety of alcohols, oils, and an alkali-soluble resin have been recovered. The alcohols in-

clude methyl alcohol (wood alcohol or methanol) and propyl alcohol, and previously unknown products of the hydrogenation include a hard, glossy, amber-colored resin that may prove useful for plastics and lacquers, and several derivatives of propylcyclohexane, some of which are thick viscous oils and others thin and toxic in nature. The apparent utility of these products has not been subjected to practical tests.

When the whole wood complex is subjected to hydrogenation, the lignin fraction is resolved into the components just described and the cellulose may be recovered in the form of a bleachable pulp of normal fiber length.

Certain products and uses of wood which return to public attention again and again with the impact of novelty are not emphasized here because they are not new. There is at least a quarter of a century of know-how and experience behind such developments as silk-like (rayon) and wool-like textile fibers from wood, automotive fuel from wood or charcoal, ethyl ("grain") alcohol and edible sugars from wood. Rayon, of course, has been manufactured largely from wood in this and other countries for years to the extent of several hundred million pounds per year. The other forest products mentioned have been and now are in use in parts of the world where economic conditions permit.

The encouraging aspect of most of the new wood products mentioned is the progress that has been made in overcoming inherent characteristics of raw wood that have limited the scope of competition with other materials. Furthermore, the prospect for continued improvement of the products and the refinement of others, already being developed under the mantle of military security, is most encouraging.

There is sound scientific basis for optimism regarding the future of wood Research at the Forest Products Laboratory and in colleges and industrial laboratories over the last third of a century has filled in long-sought details on the fundamental chemical and physical structure of wood, especially for the lignin component, and has provided the approach to new conversion processes and better control of established processes. The most promising products of wood now finding their way into important military uses and shortly to serve civilian needs had their beginnings in fundamental research, not in the uncertain resources of unguided imagination or cut-and-try empiricism. The properties of wood can now be controlled and balanced one against the other with certainty.

# COSMIC TERRESTRIAL RESEARCH

By HARLAN T. STETSON

A FEW years ago a small, enthusiastic group of business men and scientists met at luncheon to discuss plans for a new venture in science connected with the Massachusetts Institute of Technology. They forgot for the moment problems of corporations, finance, and administration to consider a new and coming field of research in cosmic terrestrial relationships—a subject made vital by the recent results of observations and deductions concerning the effect of phenomena originating outside the earth upon the science of the earth and its atmosphere. The marshaling of an array of facts demonstrating the effect of the sun's radiation upon the upper atmosphere, upon radio communication, and upon the earth's electric and magnetic fields opened up new possibilities of research in a little explored territory.

At the close of the luncheon sufficient funds had been pledged to insure, on an experimental basis, the continuance of basic research in this new field of investigation for a sufficient period to justify the venture. As a result of this conference, a new Laboratory for Cosmic Terrestrial Research (Fig. 1) was constructed in the suburbs of the Boston metropolitan area where observations and studies could be continued at an ideal location.

The site of the new laboratory was selected after about a year of careful study of the environs of Boston in order to find a place having suitable conditions for atmospheric electric observations and easily accessible to the Massachusetts Institute of Technology with which the work at the Laboratory is associated. The laboratory is located two miles from the center of the town of Needham in a sparsely settled residential district, ten miles southwest of Boston and industrial Cambridge. The unusually good conditions

FIG. 1. NEW LABORATORY FOR COSMIC TERRESTRIAL RESEARCH, NEEDHAM, MASS.

for radio reception have proved that the location is eminently satisfactory.

The main building comprises approximately 2,500 square feet of floor space, not including the basement in which the instrument shop is located. The building is of masonry construction and the architecture is functional modern. Interior views are shown in Figures 2 and 3. The laboratory is primarily intended for the "geophysical investigation of such relationships as may exist between cosmic phenomena exterior to the earth and such terrestrial phenomena as may result from or vary with changes in the earth's environment." A large part of the observational work being carried on relates to problems of solar radiation and atmospheric electricity, with applications to communications. The general integrated program is being carried forward under six principal subdivisions: solar studies; radio studies; auroral studies; the earth's electric field; cosmic ray observations; and certain biological phenomena.

*The Sun and Radio* Since a discussion at considerable length of the effects of solar radiation and solar disturbances upon the ionosphere and radio communication conditions has previously appeared in the June, 1942, issue of *The Scientific Monthly,* less space will be devoted here to this subject than its importance would otherwise warrant The relationship of solar disturbances, as conveniently marked by sunspots, to the electrical state of the upper atmosphere necessary for satisfactory radio communication is now so generally recognized that this part of the program of the Laboratory receives special emphasis. The long series of observations of field strengths of radio reception in the broadcasting band, first undertaken by the author in 1926, now approximates 75,000 hours, which has provided probably the largest amount of homogeneous field strength data at broadcast frequencies in existence.

The analysis of this material has shown not only a general trend consistent with the in-

FIG. 2. MAIN OFFICE AND FILING ROOM OF THE LABORATORY

FIG. 3. THE CONFERENCE AND DIRECTOR'S ROOM

verse of the sunspot curve, but has exhibited remarkable instances of long fade-outs while sunspots of unusual size pass across the line from the center of the sun to the earth. The remarkable increase in radio fields in passing from daylight to darkness, and the marked seasonal variation which follows the changing declination of the sun from summer to winter, are probably the most pronounced demonstrations of radical changes in the electrical state of the upper air under the influence of the sun. A wholly unexpected annual variation has been discovered that is not explained by any seasonal effect. It seems to parallel closely the known annual variation in the amount of ozone in the air.

Extended studies have indicated that there is an optimum value of the ionization of the radio ceiling for the best conditions for radio transmission. Before this optimum value is reached, the reflection of the sky wave is too feeble for good signal intensity. When the optimum value is exceeded, the ionization of the layers of the atmosphere below the reflecting ceiling becomes so great as to absorb much of the energy in the radio waves and therefore again reception is below par. This indicates that a certain amount of solar activity, evidenced by a critical number of sunspots, is best suited for certain communication conditions; excesses or deficiencies in the number of sunspots with respect to the critical value result in a deficiency in radio communication. Just what amount of solar activity is necessary in the long run to produce the most favorable transmission conditions has yet to be determined.

With the added space made available at the new laboratory, at the end of 1941 we began recording the higher frequency waves such as those used in transoceanic communication (Fig. 4). Unlike the broadcast radio waves, these waves are not heavily absorbed in daylight and consequently observations of them can be made twenty-four hours a day, year in and year out.

While the broadcast waves improve many fold with the increase of darkness after sunset, the high frequency or short waves notably deteriorate from sunset to shortly before

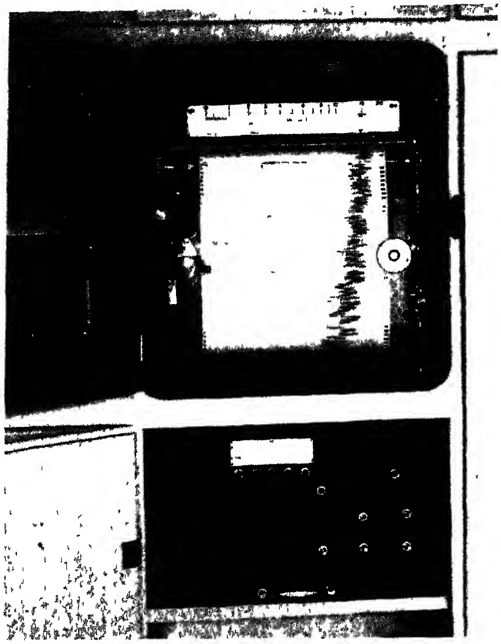


FIG. 4 MICROMAX RECORDER
USED FOR REGISTERING RADIO FIELD STRENGTHS ON HIGH FREQUENCY WAVES FROM A DISTANT STATION.

dawn. At sunrise when the solar radiation first strikes the upper atmosphere one hundred and fifty miles above the earth, the molecules of oxygen and nitrogen become instantly ionized and the reflected radio waves of a frequency of 5,000 kilocycles increase their strength over a hundredfold in the space of a very few minutes. As the sun rises higher above the horizon, the increase in ionization in the lower levels of the atmosphere absorbs the energy from these radio waves and reception deteriorates until noon. As the sun descends toward the western horizon, positive and negative ions in the air recombine and neutralize the absorbing effects in the lower layers, with the result that field strengths increase again until sunset.

Reception at even these high frequencies, however, may be totally impaired, as our records have so many times shown, when large sunspots pass over the portion of the sun facing the earth. It is truly remarkable that with the use of radio apparatus it has become possible to trace so intimately the effect of solar changes upon the electrical state of the upper air so relatively close to the surface of the earth which man inhabits.

*Effect of the Moon.* The large amount of radio data which has accumulated in the observational part of our program has made it possible to investigate what effect, if any, the moon may have upon the electrical state of the upper air. As far back as 1931 the writer showed evidence of a tidal effect of the moon upon the ionosphere or radio ceiling. Subsequent studies based on accumulating data seem to establish definitely that the electrical state of the upper air experiences variations somewhat similar to the tidal variations of the ocean caused by the moon. It was not believed that moonlight, which is only 1/300,000 as intense as sunlight, could in any way be responsible for this change. It appeared more probable that the gravitational tides set up in the atmosphere by the moon, or possibly electronic tides caused by an electrical charge on the moon different from that on the earth, was the determining factor. Some time later E. V. Appleton, a distinguished English scientist, obtained evidence from quite different observations that lunar atmospheric tides affect the radio.

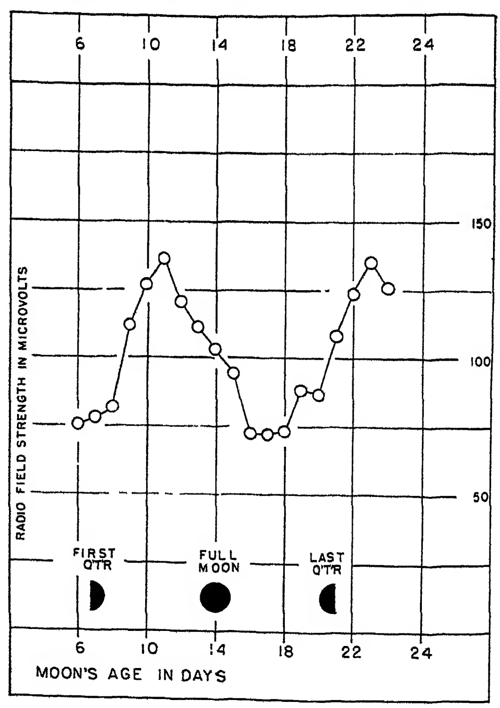



FIG. 5. RELATION OF MOON AND SUN
APPEARS TO BE A FACTOR CAUSING VARIATIONS IN FIELD STRENGTHS IN THE BROADCAST BAND. CURVE IS BASED ON RECORDS EXTENDING OVER A SIX-YEAR PERIOD.

Meanwhile, radio operators reported marked variability in radio reception with the changing phases of the moon. Although apparently unreasonable, the reports were so persistent that it seemed worth while to make an extensive study of our broadcast radio data to see whether or not there were any adequate grounds for concluding that such effects exist. It was thought that our measured field strengths would show no systematic change whatever with the changing illuminated surface of the moon. Such, however, was not the case. Contrary to all expectations, our records showed a definite improvement in radio reception from new moon until about two days before full moon, and a deterioration thereafter until near the moon's last quarter. Then there follows a subsequent recovery until two days after the last quarter of the moon (Fig. 5).

These results have led to a somewhat speculative hypothesis to account for the observed phenomena that, should it become substantiated, would appear to be revolutionary in our thinking about cosmic terrestrial relationships. This hypothesis rests upon the fact that the moon has no atmosphere and that its naked surface is exposed to an intense bombardment by the extreme ultraviolet radiation from the sun, and also by any other kind of radiation, such as electrons or high energy particles, which the sun may emit. Almost any substance subjected to ultraviolet radiation is known to emit electrons. This is the so-called photoelectric effect. Since the earth's atmosphere absorbs all this intense solar radiation, the really high-energy radiation never reaches the earth's surface. Since the moon is directly bombarded from the sun, its surface must be emitting electrons, some of which will penetrate into the earth's upper atmosphere causing ionization, which in turn could be expected to affect radio reception.

If the ionization is increased to and beyond an optimum value, radio reception will at first improve and then fade in the intensity with which it is received. This is exactly in accordance with our extensive analysis based on many thousands of hours of observational

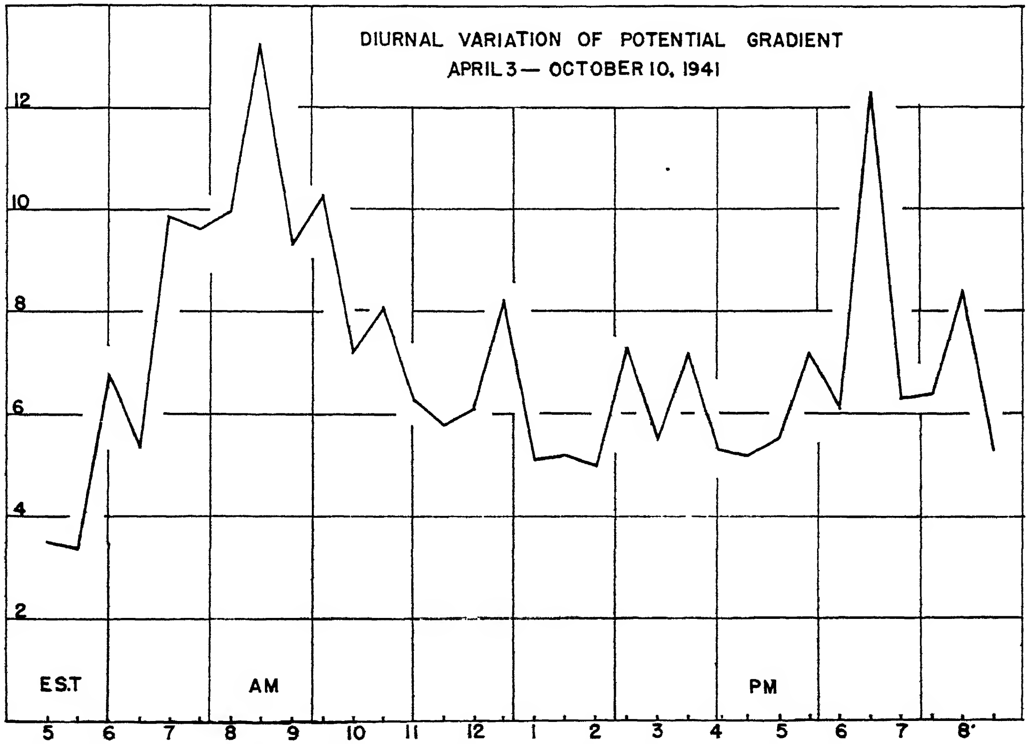



FIG. 6. DIURNAL VARIATION IN THE ELECTRICAL POTENTIAL OF THE ATMOSPHERE

data. That the observations show the existence of such an effect only on the side of the earth towards the illuminated surface of the moon appears good corroboration for the hypothesis. What is even more exciting is that this lunar effect is much more pronounced during the years of most numerous sunspots when radio observations tell us that the sun is actually sending out most energy in the ultraviolet.

There is, moreover, increasing evidence that radiation resembling x-rays may be emitted by the outer atmosphere of the sun. Such x-ray radiation striking the moon would in turn excite x-ray radiation from the elements in the moon's surface itself. The x-rays that are scattered or emitted in the direction of the earth might in turn be a factor in increasing the ionization in the earth's upper atmosphere, for x-rays are known to ionize air.

The emission of photoelectrons from the lunar surface might be expected to create an electrical charge on the moon different from that on the earth. When the moon is between us and the sun, this charge could well alter the speed and direction of charged particles emanating from the sun in the earth's direction, just as the grid in a radio tube may accelerate or retard electrons emitted from the filament in their passing to the third element of the tube. This picture, therefore, introduces us to a possible new science of *celestial electronics* that may be destined to play an important part in the field of cosmic terrestrial relationships in the coming years.

*Air Beacon Observations.* In addition to such investigations as those already described, mention should be made of systematic observations that are being made of the apparent shift in direction of the beam of a commercial radio air beacon located ten miles from the laboratory. As is generally known, the antenna of a radio air beacon is so arranged that the Morse Code signals for the letters A and N are sent out from adjacent quadrants, such as Northwest and Southeast. A pilot homing exactly on the beam hears neither of these signals but a constant hum resulting from the overlapping of both signals received simultaneously and with equal intensity. If the pilot is north of the axis of the beam, the dot-dash of the letter A predominates; if he is south of the beam, the dash-dot of the letter N predominates. The relative strength of these two signals heard from a point off the axis is, in a measure, an indication of how far the plane

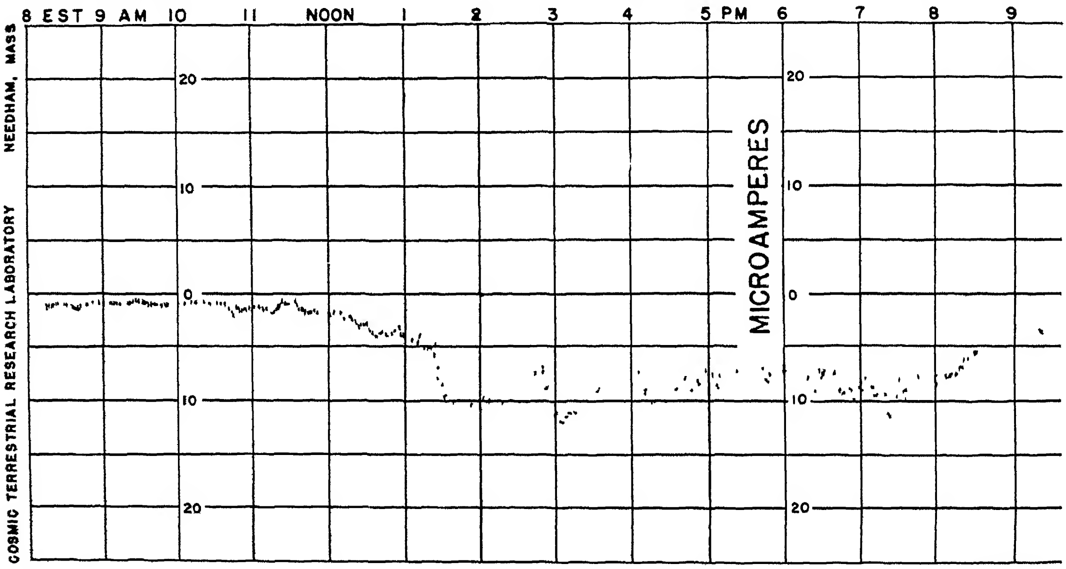



FIG. 7. ELECTRICAL DISCHARGE RECORD DURING STORM OF OCT. 26, 1943
MADE WITH POINT DISCHARGE APPARATUS, SHOWING A SKY-TO-EARTH CURRENT OF TEN MICROAMPERES.


FIG. 8. SOILLESS GROWTH OF MUSTARD PLANTS 38 DAYS FROM SEED
PLANT AT RIGHT SHOWS APPARENT STIMULATED GROWTH UNDER A POTENTIAL OF EIGHTY NEGATIVE VOLTS. A DUPLICATE SCREEN OVER THE CONTROL SPECIMEN ON THE LEFT WAS WITHOUT ANY ELECTRICAL CHARGE.

may be from the axis of the beam. The Needham laboratory lies slightly north of the axis of the beacon under observation. The field strength of the A signal compared with the N signal is measured hourly. Every effort is made at the sending antenna to maintain the output of the two signals constant, yet the ratio of these two signals as observed at the laboratory shows definitely a diurnal and seasonal variation. The ratio of A/N rises steadily after sunrise to a maximum value shortly after noon and thereafter diminishes toward sunset. Under abrupt meteorological changes the value of the ratio has been found to change systematically with the passing of a storm center. If one were to interpret the change in the ratio of A/N as equivalent to a change in the bearing of the direction of the beam, it can be said that during severe storms the apparent direction of the beam has been observed to shift by as much as 7° from its normal location with respect to the laboratory.

Careful consideration has been given to the possibility of fortuitous changes at the beacon itself, including the possible effect of unequal electrical insulation in the antenna system during rain or snow. The results, however, more definitely point to dielectric changes in the lower atmosphere or changes in ionization conditions in the tropospheric layers. Irrespective of any practical considerations that might be applicable to problems of aviation, it is believed that further investigations of this nature may yield important information as to atmospheric-electric conditions that may correlate with meteorological or other phenomena under observation at the laboratory.

*Earth's Electric Field.* The magnetic field of the earth has been known since the early writings of Gilbert in 1600. Many detailed surveys of it have been conducted because it is important that navigators know the variations of the compass. For more than a hundred years the earth's magnetic field has been known to vary with sunspots. The explanations for this relation became apparent when radio studies revealed the existence of the highly electrified shell of the earth's atmosphere, known now as the ionosphere. Electrical charges moving aloft induce magnetic currents in the earth, thus producing the slight variations in the compass needle that accompany outbreaks of sunspots.

It is probably less widely appreciated that the earth likewise has an electric field and probably carries a considerable electrical charge. Since we live on the surface of the earth it is difficult to determine the nature or the magnitude of this charge on our planet, but suitable instruments make us aware of the electrical field existing between the surface of the earth and the atmosphere above. Near the ground, during fair weather, this field amounts on the average to between 100 and 150 volts per meter. A six-foot man standing erect bridges the gap between the ground and the air at the crown of his head corresponding to a difference of potential of about 250 volts. This electrical potential between the ground and the atmosphere not only increases with height to a certain limiting value, but it is also known to vary with the time of day, the season of the year, and possibly also with the sunspot cycle. Furthermore, electricity is constantly flowing from the air to the ground. The amount is about 1000 amperes for the entire surface of the globe. What maintains this constant uni-directional flow or whether or not it is everywhere uni-directional is one of the puzzling problems of atmospheric electricity. With the establishment of the Laboratory for Cosmic Terrestrial Research, suitable apparatus for measuring the potential gradient was installed. The apparatus consists of a Wulf electrometer which measures the charge on a horizontal brass rod extending at a distance of about six feet above the ground. This rod takes up the electrical potential of the atmosphere in the immediate neighborhood by reason of a slight emanation from radioactive material in the so-called "collector" at the outer end of the rod. The collector has been supplied through the courtesy of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The electrometer is read hourly through the day and occasionally through the night.

Observations so far collected have indicated a characteristic diurnal variation in the atmosphere's electrical potential. There is a rise in the early morning to a maximum at about nine o'clock, Eastern Standard Time, and a subsequent diminution to noon. This decline is followed by a second rise during the interval from six to seven P.M., Eastern Standard Time, after which the potential gradient falls to midnight (Fig. 6).

Observations made during the celebrated cruises of the non-magnetic yachts GALILEE and CARNEGIE, 1905–1916, revealed that over the oceans there is a distinct diurnal variation exhibiting a maximum at eighteen to nineteen hours Greenwich time, no matter in what longitude the observations were made. For this remarkable phenomenon no adequate explanation has yet appeared. There is some indication that it may be related to the asymmetry of the earth's magnetic field.

In connection with atmospheric-electric observations a device for automatically recording silent electrical discharges taking place between the sky and the earth has also been installed at the Needham Laboratory. The continuous daily recordings, which have accumulated rapidly, indicate rather definite relations between the occurrence of such discharges (not including thunderstorm disturbances) and meteorological conditions. Rainstorms are in most instances accompanied by the apparent flow of electricity from the earth to the sky of an intensity of five to ten microamperes (Fig. 7). Snow is likewise accompanied by similar discharges, often reversing direction at intervals of from a few minutes to an hour or more. Abrupt meteorological changes have in rare instances been accompanied by earth-sky currents of from 50 to 60 microamperes with frequent reversals of direction. Careful studies of our records, however, have indicated no abnormal sky-to-earth discharges in the lower atmosphere at times of the displays of the aurora when the high atmosphere is turbulent with electric pyrotechnics. What relationships may exist among these sporadic atmospheric discharges, the potential gradient, radio static, and ionization phenomena are not yet known, but accumulating data offer increasing information for such a study.

*Electric Field and Plant Growth.* We are well aware of the dependence of biological growth and behavior upon solar radiation and meteorological conditions. Douglass has long since demonstrated from his lifelong study of tree-ring patterns that the

solar cycle is reflected in the growth of trees This is particularly demonstrated in selected forests of the Arizona pines and of the California sequoias. The phenomena connected with phototropism in plants have in certain instances been definitely associated with certain regions of the solar spectrum eliciting optimum response. The germination of seeds of particular species has been found dependent upon a rather critical exposure to ultraviolet light. Little has yet been done in the way of investigating possible effects of electrical fields upon plant behavior. One wonders if the varying potential gradient of the earth's field has anything whatever to do with plant growth. At least this is another one of the varying parameters with which the biologist may yet be concerned. Some experiments have been made in this direction at the Laboratory for Cosmic Terrestrial Research where tomato plants started from seed and also mustard plants germinated under laboratory-controlled conditions appear to have shown definite response to a negative potential of but relatively few volts.

In the experiments so far conducted, soilless growth has been adopted, utilizing a nutrient solution recommended by the Smithsonian Institution. In every case the nutrient solutions have been fed automatically to both the experimental plant and the control, care also having been taken to maintain the same illumination of both specimens. Figure 8 shows mustard plants thirty-eight days from seed. The experimental plant on the right was subjected to a potential gradient of eighty negative volts between the root and a screen 30 centimeters directly above the plant. The control on the left was not subjected to a potential gradient. Similar differences in growth occurred in tomato plants.

In the above instances, the voltage was arbitrarily chosen In order to attempt to discover the optimum potential gradient for greatest growth, a hydroponic trough was constructed in which plants were grown under a sloping screen to which was applied 190 negative volts with respect to the roots. The photograph (Fig. 9) is a silhouette of the growth resulting forty-three days after germination. It will be observed that at the extreme left where the potential gradient was high, the growth was markedly stunted. At the extreme right where the potential gradient was relatively low, the growth was not far from normal expectancy. A little to the right of the center of the trough, the maximum growth was obtained. A measure of the distance from root level to the charged screen in a vertical direction at this point revealed a potential gradient of approximately four volts per centimeter, which is apparently the optimum value of the potential gradient for greatest growth.


FIG. 9. PLANTS GROWN HYDROPONICALLY UNDER AN ELECTRIC FIELD GRADIENT
SILHOUETTED GROWTH CURVE SHOWS POTENTIAL GRADIENT OF 4 VOLTS PER CM. AS OPTIMUM FOR GROWTH.

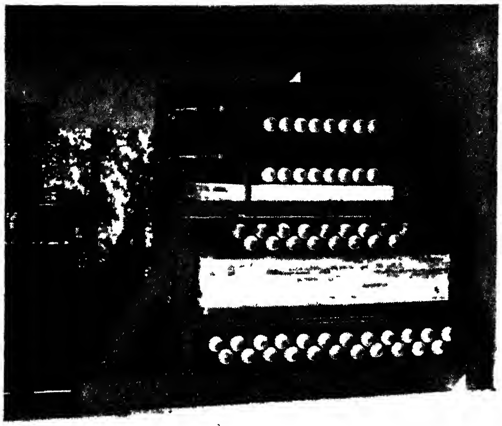


FIG. 10. COSMIC RAY APPARATUS
72 GEIGER-MULLER COUNTERS ARRANGED IN 3 BANKS; 2 TONS OF LEAD IN ABSORBING LAYERS SORT THE RAYS.

Many repetitions of the experiment should be performed under varying conditions before drawing conclusions. These preliminary attempts, however, may well lead one to speculate as to whether variations in the atmospheric potential known to exist have a significant effect upon biological phenomena in any way.

*Cosmic Ray Investigations.* The newest piece of apparatus to be added to the Needham Laboratory equipment is a multiple cosmic ray counter recently installed in connection with Massachusetts Institute of Technology's part in a program tied in with The University of Chicago and other institutions (Figs. 10–11). This elaborate equipment was especially built for the project by experts at the Ryerson Physical Laboratory of The University of Chicago. Seventy-two Geiger-Muller counters fed through an 88-tube amplifier cause the cosmic rays to click their way to a printing recorder that automatically counts hour by hour the numbers of the "rays" reaching the Earth from somewhere out in space.

The exact origin of cosmic rays is still one of those unsolved mysteries of science. Some of these "rays" are unquestionably electrons; others consist of mesotrons and protons. All are traveling at very high velocities. Some are more penetrating than others. The new machine sorts these rays into "soft," "medium," and "penetrating" radiations, and records hourly their "counts" in three divisions of the cosmic ray spectrum. Here, as in myriad other applications, electrons in vacuum tubes have been put to work gathering data.

To differentiate true cosmic rays from gamma radiation emanating from radioactive materials in the earth and air, or from strays that may enter at oblique angles, some means must be provided for insuring that the ionizing radiation actuating the Geiger tube comes from a point near the zenith. This is done by a tandem series arrangement of two or more counter tubes placed in a vertical plane so that the cosmic ray entering the first counter from directly above may also actuate the counters immediately beneath. When two or more of these counters and their input amplifiers have been actuated practically simultaneously, the current will have been closed through all input amplifiers belonging to counter tubes in the same vertical plane; then and only then will the appropriate relay respond. Stray rays coming in obliquely will activate one or the other of the amplifiers but not all simultaneously. A vertical ray on the other hand will pass through both or all within practically the same instant. Such an arrangement of counter tubes and vacuum tubes is termed a coincidence amplifier Much cosmic ray apparatus now in use is equipped with coincidence amplifiers.

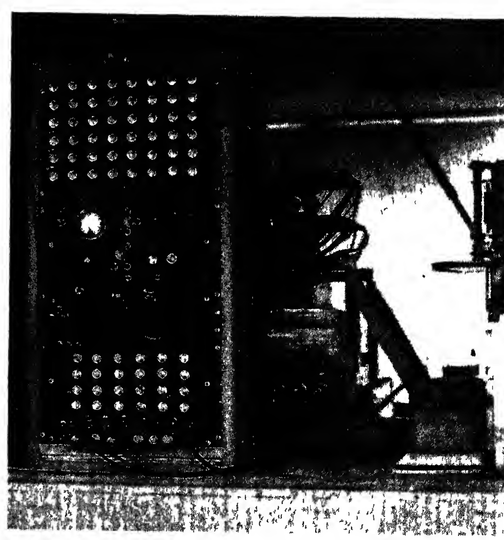


FIG. 11. THE 88–TUBE AMPLIFIER
SENDS IMPULSES FROM COUNTER TUBES TO RECORDER.

Since cosmic rays differ very greatly among themselves in the amount of energy carried, it is important to have some means of differentiating those of high penetrating power from the softer rays. This is accomplished by utilizing, as in the present arrangement, three separate banks of counters with different amounts of lead separating the banks.

The top bank, for example, which will register the softer rays, will be actuated by all cosmic radiation of sufficient intensity to penetrate the atmosphere and the walls of the counter tube. Below the top bank, sheet lead ten centimeters in thickness stops these soft rays from actuating the second bank of counters beneath. Cosmic rays of sufficient penetrating power to pass through this 10 centimeters of lead will actuate the counters in bank two. Separating bank two from bank three, the lowest layer of counters, there is an additional twenty centimeters of lead plate so that, when the counters in the bottom layer are activated, the cosmic rays responsible for the operation of these counters must have penetrated through thirty centimeters of lead altogether. These are very penetrating rays.

The counters (Fig. 10) and the 88-tube amplifier (Fig. 11) are housed in a shelter on the grounds of the Laboratory. The elaborate recording and printing mechanism is stationed inside the main laboratory, and is operated by a synchronous clock. Should any momentary interruption of the power supply occur, the apparatus is automatically cut out and must be manually reset. This is to avoid any uncertainty as to the correct interpretation of hourly counts.

So interrelated are the problems in these many different but allied fields of science that no one specialist in any one field can hope to cope with all their implications. Astronomy, meteorology, atmospheric electricity, geophysics, communication engineering, and even biology meet in common territory when we seek the solution of problems in cosmic terrestrial relationships. Here specialists must concern themselves with the synthesis of knowledge gleaned from the sky above to the earth below.

Too long, perhaps, has science delayed in apprehending the cosmic environment of the earth as an important factor in the geophysics of our planet. Furthermore, we are becoming increasingly aware that man himself is a highly articulated organism whose activities and even whose metabolic processes are quite dependent upon the quantity and quality of sunlight and the circumstances of his terrestrial environment. Even all life has revealed itself as electrical in nature. The mysterious electron, a fundamental building block of matter which dances in our radio tubes to the tunes of our favorite orchestra, dances likewise in the atoms of the distant stars, in the vast interstellar spaces, and in man himself. We are indeed entering upon a strange new world of thought in science—perhaps as strange as was the Copernican doctrine of a heliocentric universe to the medieval mind of three hundred years ago.

What implications the future may hold we cannot now foresee. Perhaps a note of caution should be sounded lest the over-enthusiastic indulge in unwarranted speculation. To the less imaginative Horatios:

> There are more things in heaven and earth, Horatio,
> Than are dreamt of in your philosophy.

# PRESIDENTS OF STATE UNIVERSITIES

By JAY C. KNODE

A STUDY of the academic backgrounds of state university presidents of the year 1941 compared with similar backgrounds of the presidents of the same institutions in 1916 shows certain definite trends. The data used herein were obtained from the two corresponding editions of *Who's Who in America*. The membership list of the National Association of State Universities for October 31, 1941, contained the names of fifty-two administrative heads of institutions and systems. Forty-seven of these presidents of universities in the continental United States (including two presidents-elect) were compared with the heads of the same institutions twenty-five years earlier.

The first item observed was the positions from which presidents stepped into the headship of a university. These positions were classified as those of professor, dean or director, vice-president, president of another educational institution, and positions not connected with higher education. The figures for the two years are shown in Table 1.

TABLE 1
DISTRIBUTION OF FORMER POSITIONS OF PRESIDENTS OF 47 STATE-SUPPORTED UNIVERSITIES IN 1916 AND 1941

| Position | 1916 | 1941 |
|---|---|---|
| Professorship | 17 | 9 |
| Dean or directorship | 14 | 19 |
| Vice-presidency | 0 | 5 |
| Presidency of other institution | 9 | 6 |
| Other than college work | 7 | 8 |

Deanships included those of administration and instruction; directorships included one of an agricultural experiment station. Others were of the kinds familiar on most large campuses. The positions outside college work in the 1916 list included the directorship of religious education for the national organization of one of the Protestant churches, but the holder of this position had been a former university president. Similarly, one in the 1941 list went from the position of city manager, but had previously held a professorship of municipal administration, and another, though vice-president of a large commercial concern when elected, had been an associate professor of business. A few of those not connected with higher education were called from judgeships and the practice of law, but more went from positions connected with public school systems.

Table 1 is computed upon the basis of the immediately preceding positions left by presidents when they assumed headships of state-supported universities. The striking point here is the increase in emphasis upon previous educational administrative experience. The professorship as a source of presidential timber dropped virtually 50 percent; deanships and directorships rose more than 35 percent, and vice-presidencies 100 percent. Of the 39 coming directly from college positions in 1941, 74.4 percent had had administrative experience; in 1916, of the 40 coming from college positions 57.5 percent had administrative backgrounds in higher education.

The study was extended to include the two immediately antecedent offices. It was then found that only three of the 1941 list had not had executive experience in either of their two preceding positions. These men came from professorships of economics, history, and physics. In the 1916 list fifteen of the seventeen listed in Table 1 had not done administrative work in either of their two previous positions. The list included such men as: William Lowe Bryan, from Greek and philosophy; Livingston Farrand, from psychology and anthropology; Jacob Gould Schurman, from philosophy and English literature; Henry Suzzalo, from philosophy of education; Charles Richard Van Hise, from geology; and Benjamin Ide Wheeler, from Greek, Latin, and German. Another item of interest is that out of the 1941 list four men at some time previous to their election to a presidency had been deans of schools of business and one had been a

comptroller. These categories did not appear in the 1916 list.

A study of degrees held by presidents shows little variation in the pattern for the Ph.D., but the complete disappearance of the honorary D.D. and the appearance of advanced earned degrees in law and education in the contemporary list mark a new shift. A numerical comparison is made in Table 2.

TABLE 2

HIGHEST EARNED DEGREES HELD BY PRESIDENTS OF 47 STATE-SUPPORTED UNIVERSITIES IN 1916 AND 1941

| Degree | 1916 | 1941 |
|---|---|---|
| Ph.D. | 23 | 21 |
| Master's Degree | 13 | 12 |
| Bachelor's Degree | 7 | 6 |
| S.J.D. or J.D. | 0 | 2 |
| M.D. | 1 | 0 |
| Ed.D. | 0 | 1 |
| LL.B. | 0 | 4 |
| C.E. | 1 | 1 |
| M.E. | 1 | 0 |
| No Degree | 1 | 0 |

In 1916 two of the holders of the master's degree and two of those with the bachelor's degree held honorary D.D. degrees. No one held this distinction in 1941. Further, it should be pointed out that, in addition to the six men indicated as holding law degrees in 1941, two others with the Ph.D. degree had also earned the LL.B., making a total of 8, or a little more than 17 percent of the total of 47 possessing degrees in law. Among the 1916 list no one held such a degree, but the one president without a degree had been advanced to his office from the bench of a Circuit Court of Appeals.

The third comparison undertaken was relative to the academic fields of interest of the two groups. It was possible to trace this through the teaching done by 37 of the 1916 group and by 39 of the 1941 group. Subjects were grouped among humanities, social sciences, natural sciences and mathematics, and professional subjects. Some difficulty in classification was encountered owing to the fact that several men had divided their teaching loads, but approximate results are shown in Table 3 by percentages.

TABLE 3

FIELDS OF TEACHING OF 37 PRESIDENTS OF STATE-SUPPORTED UNIVERSITIES IN 1916 AND OF 39 PRESIDENTS IN 1941

| Field of Teaching | 1916 | 1941 |
|---|---|---|
| | Percent | Percent |
| Humanities | 32.9 | 7.7 |
| Social Sciences | 28.6 | 30.8 |
| Natural Sciences and Mathematics | 27.1 | 12.8 |
| Professional Subjects | 11.4 | 48.7 |

Here, perhaps, is the most striking evidence of the change in the complexion of state university administration. Teaching experience in the social sciences has remained about the same, but the proportion in the humanities has shrunk by more than 25 percent and that in mathematics and the natural sciences by nearly 15 percent. On the other hand, presidents with predominant professional interests outside the usual academic fields, as indicated by their teaching, increased by more than 37 percent. Those interests represented professions as varied as engineering, education, mining, agriculture, law, business administration, and military science. Those with a teaching background in business administration increased from 0.0 to 5.1 percent; in law, from 0.0 to 7.7 percent; in education, from 8.1 to 20.8 percent.

The simplest generalization that can be made seems to be that state-supported universities in 1941 were being headed by men whose backgrounds contained more practical administrative and business experience and training than the backgrounds of presidents in 1916. Far fewer professors were called to presidencies because of their scholarly reputations. The three predominant professional fields outside the usual academic departments of the university from which presidents were being recruited in 1941 were law, business, and education. The social sciences are, of course, most closely related to these subjects. Mathematics, the natural sciences, and especially the humanities are apparently no longer regarded as contributing essential or important backgrounds.

It is not difficult, of course, to point out at least one factor that has led to emphasis

upon administrative ability. Comparison of reports from the United States Office of Education for the years 1916 and 1938 shows that the enrollment of the 47 institutions here under consideration increased from 94,600 to 258,900; the numbers of their faculties from 8,600 to 25,200; the value of their property from $111,000,000 to $448,000,000. It was the period of the "great rush" into secondary and higher education. State universities became huge institutions. No state government could overlook so powerful an agency within its borders, especially when legislatures were confronted by calls for appropriations which demanded close scrutiny. Legislators think in terms of business. They expect institutional heads to talk in those terms. Conversely, from within the institution and from its alumni came demands for leadership which, first of all, could obtain adequate financial support.

Manifestly the phases of the work of the state university president which now loom largest before the American public are practical and political. Whether men of these qualities can combine with them the educational and scholarly vision essential to the fulfillment of American destiny through coming generations as conceived one hundred fifty years ago "doth not yet appear."

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## CURRENT LIST OF MEMBERS OF THE NATIONAL ASSOCIATION OF STATE UNIVERSITIES, WITH NAMES OF PRESIDENTS

| Institution | President 1943–44 |
|---|---|
| University of Alabama | Raymond R. Paty |
| University of Arizona | Alfred Atkinson |
| University of Arkansas | Arthur M. Harding |
| University of California | Robert G. Sproul |
| University of Colorado | R. G. Gustavson, acting |
| University of Connecticut | Albert N. Jorgensen |
| University of Delaware | Walter Hullihen |
| University of Florida | John J. Tigert |
| University of Georgia | Harmon W. Caldwell |
| University of Hawaii | Gregg M. Sinclair |
| University of Idaho | Harrison C. Dale |
| University of Illinois | Arthur C. Willard |
| Indiana University | Herman B. Wells |
| State University of Iowa | Virgil M. Hancher |
| University of Kansas | Deane W. Malott |
| University of Kentucky | Herman L. Donovan |
| Louisiana State University | Campbell B. Hodges |
| University of Maine | Arthur A. Hauck |
| University of Maryland | Harry Clifton Byrd |
| University of Michigan | Alexander G. Ruthven |
| University of Minnesota | Walter C. Coffey |
| University of Mississippi | Alfred Hume, acting |
| University of Missouri | F. A. Middlebush |
| Montana State University | C. W. Leaphart, acting |
| University of Nebraska | Chauncey S. Boucher |
| University of Nevada | John O. Moseley |
| University of New Hampshire | Position to be filled |
| Rutgers University (N. J.) | Robert C. Clothier |
| University of New Mexico | James F. Zimmerman |
| Cornell University (N. Y.) | Edmund E. Day |
| University of North Carolina | Frank P. Graham |
| University of North Dakota | John C. West |
| Miami University (Ohio) | Alfred H. Upham |
| The Ohio State University | Howard L. Bevis |
| Ohio University | W. S. Gamertsfelder |
| University of Oklahoma | Position to be filled |
| University of Oregon | Position to be filled |
| Pennsylvania State College | Ralph D. Hetzel |
| University of the Philippines | Position to be filled |
| University of Puerto Rico | Jaime Benítez |
| University of South Carolina | J. R. McKissick |
| University of South Dakota | Ila Delbert Weeks |
| University of Tennessee | James D. Hoskins |
| University of Texas | Homer P. Rainey |
| University of Utah | LeRoy E. Cowles |
| University of Virginia | John L. Newcomb |
| University of Washington | Lee Paul Sieg |
| West Virginia University | Charles E. Lawall |
| University of Wisconsin | Clarence A. Dykstra |
| University of Wyoming | James L. Morrill |

# BIRDS PICKABACK

By W. L. McATEE

Most birds seem too wary to be riders and too touchy to be ridden, yet some birds do indulge a good deal in pickaback. The evidence that they do so varies from fact to folklore. The visitor to a zoological garden may from time to time see a number of the animals involved, some of them strange associates for birds. Particularly strong is this impression with respect to the treacherous crocodile and the formidable rhinoceros, but each has a bird attendant so characteristic that it bears its giant companion's name.

The crocodile-bird, the so-called Egyptian plover, is a courser that alights on crocodiles to find and devour their parasites and even enters their mouths to catch flies. Ordinarily, creatures that go into crocodiles' mouths do so involuntarily and never return, but the crocodile-bird, as an exception, is living proof that the crocodiles recognize it and appreciate its services. White egrets also are credited with a sort of valet relationship with crocodiles, as are sun-bitterns with American tapirs.

So burly and irascible are rhinoceroses that they would seem anything but attractive consorts for birds. However, two kinds of African birds allied to the starlings settle on the backs of these dinosaur-like monsters to remove bots and ticks. Rendering the same sanitation for camels and cattle, these birds are also called ox-peckers. Alfred Newton says, "Though the animals are at first alarmed at the visitation, they soon get over the fright, regarding . . . with evident pleasure the way in which the birds creep about them and rid them of the pests." Herbert Friedmann informs me that the ox-peckers also alight on bustards and ostriches. Whether the purpose is the same as when they perch on the large mammals is a question, but the fact is of interest as an illustration of bird riding upon bird—the particular form of pickaback that is the main subject of this essay.

Elephants, though larger than rhinoceroses, are not as irritable and are thus perhaps more attractive to bird attendants. W. P. Pycraft states that egrets in Africa swarm over the bodies of elephants and catch insects put up by the animals. In the New World sun bitterns similarly associate with tapirs. Becoming accustomed to riding upon wild creatures, it was an easy transition to pickaback on the easy-going and patient, domesticated livestock. From this habit, certain white herons are known as cattle egrets. Their natural hosts are the redoubtable water buffalos which, though dangerous when aroused, have been reduced through long breeding and training to manageable strains useful to man. Egrets and other small herons seem to have a tendency almost everywhere to associate with cattle and other stock, upon which they sometimes perch. In this country, Herbert L. Stoddard reports a few instances of seeing snowy egrets, and one of a little blue heron, on the backs of hogs. He has also seen an egret of this same species on a cow.

The birds that frequent domestic stock do so for two principal reasons: to search the bodies of the animals for edible parasites, and to glean insects attracted to the stock or flushed by its trampling or grazing. Certain groups of birds have evident predilections for these specialized modes of feeding. The mynas, starlings, and their allies, and the anis, and cowbirds and blackbirds quite characteristically feed on and about cattle; the shrike-like drongos of Asia (according to H. G. Deignan) and certain flycatchers come to cattle for flies or even use them as vantage posts from which to swoop upon insects stirred up by the animals. This association was recognized in the design of an archaic Greek coin which showed a cow with a bird on its back. There has been some dispute among classicists as to the identity of the bird, but if an ornithologist were asked to name it on the basis of greatest probability, he would say the starling.

In Africa a starling (*Sturnopastor*) and in North America the cowbirds (*Molothrus*) have won the name buffalo bird from their association with the water buffalo and the

bison, respectively. Edwin James, botanist on Long's Expedition of 1819–20, notes that the bisons "from their submission to the pressure of numbers [of these birds] . . . seem to appreciate the services they render, by scratching and divesting them of vermin."

Cowbirds, writes E. T. Seton, "haunt the buffalo as negroes do a Mississippi rafthouse; sometimes on it, sometimes on the nearest land, but always moving when it moves, and recognizing it as headquarters." He notes an instance of a cowbird surviving the winter at Winnipeg, Canada, by warming itself on a bison's back by day and sleeping in a hollow it had snuggled in the animal's hair. An Indian myth asserts that the cowbird nests in the wool between the horns of the buffalo. Unfortunately for this story, the cowbird does not nest at all, foisting its eggs for hatching upon a variety of foster parents. A number of early explorers of the west reported cowbirds, or prairie blackbirds as they called them, as alighting not only upon buffalos but also on horses and mules and even on men. Lewis and Clark of the famous expedition sponsored by Thomas Jefferson called the cowbirds buffalo peckers. In more recent times they have taken in the same way to sheep and hogs, and Herbert Friedmann has seen them perch upon elands, yaks, and emus in zoos.

Cowbirds are of the blackbird alliance, and their kin, Brewer's blackbird, a western species, has been recorded as a pickaback upon sheep. The writer has seen boat-tailed grackles, of the same family, swarming about cattle in Louisiana, jumping up from the ground to snap ticks or flies from the animals' bellies and clambering all over them, even climbing up and down their tails. By measurement these birds are about the same size as fish crows, although proportionally more is allotted to tail, and it seems remarkable that the cattle should tolerate such intimate attentions from them.

Anis represent another group of birds—the cuckoo tribe—among the perchers on cattle. Their purpose in visiting the animals is so obvious that it has earned for them the name of tickbirds and what amounts to the same thing in Spanish, *garrapateros.*

Among the flycatchers, the common phoebe of the eastern United States, according to an observation of the writer, under certain circumstances will pick insects from a domestic animal. Years ago at the Santee Club, South Carolina, on a drizzly, winter morning when insects doubtless were all but banished from the air by the cold and rain, a phoebe was seen hovering about a cow and at times clinging to her hair while it snapped up the insects attracted by the shelter and warmth of the animal's body.

The short-winged tyrant flycatchers of Argentina have more than once been recorded as attending cattle. W. H. Hudson wrote of them in 1888, "They haunt the cattle-pens, and become extremely familiar with the cows, horses, and sheep, following them to the pasture grounds, where they are often seen perched on the back of a horse or other domestic animal, or stationed close to its nose on the ground, watching for insects." The fire-crowned tyrant of Brazil is an associate of the marsh deer upon which it is known to alight.

The perching of birds upon animals is not altogether an innocent and mutually advantageous arrangement; like so many relations, it has become perverted in some instances and has a sinister side. The case of the kea is well known; this New Zealand parrot goes on from eating carrion of sheep to digging through the wool and flesh of the living animals to get the kidney fat. In our Western States, magpies begin by picking warbles from the hides of cattle and continue by tearing away adjacent tissues; they also take advantage of other wounds; and in both ways sometimes do enough damage to cause death of their victims. Recently under stress of winter weather that made food hard to find, starlings in flocks have imitated the magpies and incurred the wrath of the stockmen.

A few instances have been mentioned of birds alighting on other birds and these are guides to the heart of our subject of bird pickaback. Naturally, large kinds are the bearers and smaller ones the riders. As noted, ostriches and bustards are sought by the ox-peckers. Ostrich stature need not be particularized, but it may be well to state that bustards are of the size of our wild turkey or somewhat smaller. One of them,

the crested bustard of East Africa, according to W. P. Pycraft, is habitually perched upon by the rosy bee-eater as a watch post from which to capture insects. An interesting account of pickabacking, involving storks and flycatchers, may well be quoted from the famous explorer Samuel W. Baker. Near the Blue Nile in Abyssinia, he writes:

During the march over a portion of the country that had been cleared by burning, we met a remarkably curious hunting-party. A number of the common black and white stork were hunting for grasshoppers and other insects, while mounted upon the back of each stork was a large copper-colored flycatcher, perched like a rider on his horse, keeping a bright look-out for insects, which from its elevated position it could easily discover. . . . I watched them for some time; whenever the storks perceived a grasshopper or other winged insect, they chased them on foot, but if they missed their game, the flycatchers darted from their backs and flew after the insects like falcons, catching them in their beaks, and then returning to their steeds to look for another opportunity.

Some birds should be accustomed to pickaback, as they begin young. Who has not seen domestic chicks, or peepies, climbing about or resting upon a reclining hen? When she gets up and begins to walk, however, they cannot stick but despite every effort slide off, breaking the fall by flapping their little wings. The same chick behavior is seen in related birds, as the bobwhite and ruffed grouse, and may be generally characteristic of the grouse-quail-partridge alliance. The young of certain water birds succeed better as jockeys, riding their parents who can swim so much better and faster than they. Birds manifesting this habit are the grebes, loons, and swans. In 1672, Nicolas Denys wrote that great auks carry the young on their backs and take them as far as the Bank—presumably the Great Bank off Newfoundland.

It seems possible that parental aid may be in some instances extended to young that are well grown. One further step would result in similar collaboration among adults. There are apparent illustrations of both of these traits. As to the first, George H. Mackay, a New England sportsman of the highest veracity, wrote in the leading American ornithological magazine on the "Behavior of a Sandhill Crane":

While shooting near Madelia, Minnesota, one autumn day some years ago (Oct. 1 or 2, 1873), my companion, Mr. Horace Thompson of St. Paul, slightly wounded with a rifle ball at long range an immature Sandhill Crane (*Grus mexicana*) which with several others was resting on the prairie. At the report they all flew away except the wounded bird and one other which apparently was its parent. The wounded bird, after a number of unsuccessful attempts to fly (assisting itself by first running, accompanied by the parent which kept beside it), finally succeeded in rising some ten or fifteen feet from the ground, but it evidently could not long sustain itself in the air. The parent bird, perceiving this, deliberately placed itself *underneath* the wounded one, allowing it to rest its feet on her back, both birds flapping away all the while. In this position she actually succeeded in bearing it off before our eyes for quite a distance to a place of safety, where we would not follow it. It was one of the most touching examples of parental affection in a bird that has ever come under my observation.

The other illustration, attributable to no individual, and not as clear cut, may be worth citing from the authority of *Forest and Stream* in which it appeared. It alleges assistance in flight to a wounded member of a flock of Canada geese.

It is undeniable that the young of certain birds ride their parents and that some adult birds habitually perch upon stationary or even slowly moving animals, including larger members of their own order. The question remains whether any birds are carried by their fellows in full flight. Folklore says they are; science does not know.

According to Ernest Ingersoll, "The Arawak Indians of Venezuela relate that their ancestors obtained their first tobacco plants from Trinidad by sending a hummingbird, mounted on a crane, to snatch and bring back the jealously guarded seeds."

The European quails, smaller than ours but with similar short, cuppy wings adapted to swift bursts of flight but apparently not to protracted migration, nevertheless cross the Mediterranean Sea. Unable to believe that they do so under their own power, people conceived the idea that they make the journey as passengers upon cranes. Pierre Belon mentioned this belief in 1555, but it is much older, in fact it is traditional. The Tartars of Siberia believed that corn-crakes were carried southward by cranes.

Henry J. Van-Lennep refers to small bird travel by cranesback in his book *Bible Lands* (1875) but writes as one assuming, rather than proving, the fact. He says, in part:

We have often been struck with the great number of birds, particularly of the smaller species, which inhabit Western Asia, as compared with Europe and North America. We have so often made this observation upon the three continents, that it seems to be a fact settled beyond a doubt. The most natural explanation of this circumstance lies in the fact that the feathered tribe, even those of feeblest wing, have an easy road from Palestine, Syria, and Mesopotamia, by the Isthmus of Suez, and over the narrow Red Sea, to their winter-quarters in tropical Africa, while nature has provided them with extraordinary means of conveyance from Asia Minor southward across the Mediterranean, which will presently be described. . . . He who is ever mindful of the smallest of his creatures has provided them with means of transportation to a more genial clime. Many of them, indeed, find their way downward from Palestine into Arabia and Egypt, but this would be difficult, if not impossible, where lofty mountains and broad seas intervene; and to meet such cases the crane has been provided. . . . In the autumn, numerous flocks may be seen coming from the north with the first cold blasts from that quarter, flying low, and uttering a peculiar cry as if of alarm, as they circle over the cultivated plains. Little birds of every species may then be seen flying up to them, while the twittering songs of those already comfortably settled upon their backs may be distinctly heard. On their return in the spring, they fly high, apparently considering that their little passengers can easily find their way down to the earth.

It is not clear whether this author means that he has personally seen the phenomenon described; another writer implies that he has, but he remains unidentified. In a letter published in the *New York Evening Post*, November 20, 1880, a correspondent using the pseudonym, "Phone," writes of "The singular methods of travel the wagtail adopts to cross the Mediterranean Sea." He says, "In the autumn of 1878, on the Island of Crete, the village priest called my attention to the twittering and singing of small birds distinctly heard when a flock of cranes passed on their southward journey. Upon discharge of a gun, three small birds were seen to rise from the flock and soon disappeared among the cranes."

If "Phone" had been George Newbold Lawrence, an eminent New York ornithologist of the period, or were otherwise identified as an accurate and credible observer, we should perforce believe that there is something in the crane ferrying services. As it is, we can only conclude, "interesting if true."

References, the originals of which have not thus far been seen by me, quote a German author as saying it is "believed at Cairo that wagtails and other small birds cross from Europe to Nubia and Abyssinia on the backs of storks and cranes," and a Swedish traveler as stating that on the Island of Rhodes "where the storks came in flocks over the sea . . . he often heard the notes of small birds, without being able to see them; but on one occasion he observed a party of storks just as they alighted, and saw several small birds come off their backs."

As reported in North America on the basis of Indian belief, a supposed instance of crane-assisted migration has various points of dubiety. It was recorded by J. C. Merrill, an accomplished and reputable bird student, but only upon hearsay. There is a general belief among the Crow Indians of Montana, he notes, that a bird, apparently a grebe, which they call the cranesback, arrives and departs with the sandhill crane. "About ten or fifteen per cent. of cranes are accompanied by the 'crane's back,' which, as the crane rises from the ground flutters up and settles on the back between the wings, remaining there until the crane alights." The Cree Indians have a similar story involving the white or whooping crane.

In comment, it must be said that grebes are birds of rather substantial size, and a pound or more in weight, which can by no means nestle among the feathers of cranes, and that their feet are very ill-adapted to clinging to anything. The Indian legend refers to "a constant chattering whistle" made by the alleged crane riders and grebes have no such note.

Ernest Ingersoll again contributed an interesting item to the record, saying:

Mr. E. Hagland, of Therien, Alberta, wrote to me as follows in a casual way, without any prompting, in April, 1919: "One fall a flock of cranes passed over me flying very low, and apart from their squawking, I could distinctly hear the twittering of small birds, sparrows of some kind. The chirping grew louder as the cranes drew towards me, and grew fainter as they drew away; and as the cranes were the only birds in sight I concluded that little birds were taking a free ride to the south."

In writing of the Canada goose, John Rae, the well-known explorer, states:

The Cree Indians at both these places [Moose and York Factories], assert positively that a small brown

bird uses this goose as a convenient means of transport to the north, and that they have been often seen flying off when their aerial conveyance was either shot or shot at. The little passenger has been pointed out to me, but I have forgotten its name. Certainly it makes its appearance at the same time these geese do, which, by the way, are the only kind that are said to carry passengers. The natives of the Mackenzie River, more than a 1000 miles to the north-west, tell the same story, so I believe in its truth.

In a separate statement Rae says, "An intelligent, truthful, and educated Indian named George Rivers, who was frequently my shooting companion for some years, assured me that he had witnessed this, and I believe I once saw it occur."

John Richardson sharpens the details of this story but does not, like Rae, affirm that he accepts it. His account is:

The Indians believe that a small finch [the Lapland longspur] (*Plectrophanes lapponica*) avails itself of the strength of wing of the Hutchin's goose, and nestles among its feathers during its flight. When a goose is shot, they often see the small bird flying from it. Neither Mr. Rae nor I noticed such an occurrence, nor did I obtain a confirmation of it from the personal observation of any of the gentlemen resident in the country, but it is generally affirmed by the Indians.

A related item involving Maine Indians is given by A. F. Gilmore in a book published in 1919:

The old Penobscot Indian who sometimes acts in the capacity of guide on my excursions into the north woods assures me that his tribe believe that all the 'little chip birds' make the long migrating journey by clinging to the backs of the larger birds, strong fliers as Loons, Geese, Ducks, Herons, etc., stealing a ride as it were.

What is perhaps only an example of "newspaper science," from a St. Louis journal in November 1936, alleges that a hummingbird was found nestled in the feathers of a Canada goose shot at Williams Lake, British Columbia.

European geese are mentioned as migration aiders in one rather roundabout record. A correspondent of the *London Field* gives his recollection of an article in the *Newcastle Weekly Chronicle* to the effect that an English ship's captain saw in the Strait of Gibraltar a flock of geese passing from the African to the European coast. With the glass, small birds about the size of larks were seen to rise from the backs of the geese and to return. The observation is said to have been verified by several people.

Now for a most circumstantial account of avian pickaback, involving a smaller bearer than any previously mentioned. T. H. Nelson, the correspondent just referred to, had it from a Mr. Wilson, foreman on the South Gare Breakwater at the mouth of the Tees River, England. Wilson said:

I was at the end of the Gare on the morning of the 16th of October [1879] and saw a "Woodcock Owl" [short-eared owl] come flopping across the sea. As it got nearer I saw something sitting between its shoulders, and wondered what it could be. The Owl came and lit on the gearing within ten yards of where I was standing, and, directly it came down, a little bird dropped off its back and flew along the river. . . . We followed the little bird and caught it.

Nelson was shown the specimen, which was a golden-crested wren or kinglet, and he says, "I have every reason to believe that what I have written is correct."

Are we, as distant reviewers, to believe these tales or to reject them? "Where there is so much smoke, there must be some fire," goes the adage, and we may well heed it in judging the evidence presented as to birds riding upon birds. Knowing that tired migrants alight upon moving vessels, we should not doubt too strongly that they sometimes avail themselves of transport by large birds. Admitting that this pickaback phenomenon actually occurs, we need not grant, however, that it is an important factor in bird migration. For one reason, small birds always outnumber the large and could by no means find accommodation on their backs. For instance, the longspur riders of one of the American tales number thousands to the hundreds of their supposed steeds, the Canada geese, and some such disproportion of numbers prevails in every case. Manifestly pickabacking cannot be a major factor in migration. Yet as to its simple occurrence, there can hardly be disbelief.

Legendry is even more hospitable to strange beliefs than are younger stages of folklore, hence we are not surprised to learn that the very widespread European tradition of the sovereignty of the wren over all birds has a pickaback basis.

The following version is taken from Thompson's "Birds of Ireland." . . . In a grand assembly of

all the birds of the air, it was determined that the sovereignty of the feathered tribe should be conferred upon the one who should fly highest. The favorite in the betting was of course the eagle, who at once, and in full confidence of victory, commenced his flight towards the sun: when he had vastly distanced all competitors, he proclaimed with a mighty voice his monarchy over all things that had wings. Suddenly, however, the wren, who had secreted himself under the feathers of the eagle's crest, . . . popped from his hiding-place, flew a few inches upwards, and chirped out as loudly as he could, "Birds, look up and behold your king!"

A German version substitutes the stork as carrier.

Algonquin Indians of America had a similar myth relating to a linnet and eagle but it had a more practical ending. In a test as to which bird could fly highest, the eagle flew as high as it could "when the gray linnet, a very small bird, flew from the eagle's back, where it had perched unperceived, and being fresh and unexhausted, succeeded in going the highest." However, the eagle was given the prize because it had carried the linnet on its back.

In the Western Hemisphere, we have various birds which temporarily ride other birds. Hummingbirds of a variety of species do this in defense of their nesting territories. The Argentine chope, a blackbird closely related to the boat-tailed grackle previously mentioned, according to W. H. Hudson, fights off predatory birds even as large as the caracara eagle, "pouncing down and fastening itself on the victim's back, where it holds its place till the obnoxious bird has left its territory."

The legends previously referred to concerned stratagems to obtain recognition as king of birds, but in America we have in real life a pickaback bird which at every opportunity asserts its right to the title "king." This is the well known bee-martin, or kingbird, which attacks other birds regardless of size. Crows, hawks, vultures, and eagles, look alike to him. Either because of his smaller size and adroitness or because he really bluffs them, he seldom meets resistance. Screaming malediction and defiance, he pecks at them, pulls their feathers, and literally rides them off the field of battle.

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## THE CRANE'S BACK

I notice that in the *Forest and Stream* of Dec. 23 you reprint a letter published in the *Evening Post* on the subject of wagtails crossing the Mediterranean Sea on the backs of cranes and storks. This has the indorsement of the eminent ornithologist von Heuglin, and induces me to report a general belief among the Crow Indians of Montana that the sandhill crane performs the same office for a bird they call *napite-shu-utle* or "the crane's back." This bird I have not yet seen, but from the description it is probably a small grebe. It is "big medicine," and when obtained is rudely stuffed and carefully preserved. I hope to have one brought to me soon for identification . . . . many of their hunters and chiefs have assured me that they have frequently seen the birds carried off in this way. At these times the bird is said to keep up a constant chattering whistle, which is the origin of the Crow custom of warriors going into battle each with a small bone whistle in his mouth; this is continually blown, imitating the note of the crane's back, and, as they believe, preserves their ponies and themselves from wounds, so that in case of defeat they may be safely carried away as is the *napite-shu-utle*. The Cree Indians are said to observe the same habit in the white crane.—J. C. MERRILL, *Forest and Stream*, March 10, 1881, p. 105.

# THE BRAZILIAN RACIAL SITUATION

By DONALD PIERSON

PROBABLY the most significant and far reaching event of the past five hundred years has been the expansion of western Europe. Its ecological, economic, political, and cultural consequences have extensively modified human living throughout virtually the entire world and, incidentally, have presented us with most of our present social and cultural problems.

Although the general character of the expansion of western Europe is familiar, it may be useful to recall here some of the more important incidents connected with it. For instance, extensive explorations and discoveries from the fifteenth to the present century have made known to large numbers of Europeans even the most inaccessible outlying regions. Invasion and conquest, the establishment of mandates and protectorates, the demanding and obtaining of extraterritorial rights had at the outbreak of the present war brought under European political control 84 percent of the world's surface and 69 percent of its peoples. Moreover, in the course of this expansion, widespread dispersions of population have occurred. Large numbers of Europeans left their homes and migrated to other lands, especially to the New World, but also to Australia, to New Zealand, to South and North Africa, and to other areas. At the present time it is estimated that there are approximately 160 million people of European origin living outside Europe.

As one of the consequences of the several attempts of these European peoples to root themselves in new habitats, an extensive slave trade developed which, combing the coasts and interior regions of Africa for approximately four centuries, transported millions of Africans into the United States, the West Indies, and Brazil. And, following the abolition of slavery throughout the British Empire in 1833 and, by 1865, in nearly all parts of the world, the development of a contract labor system had as one of its results the migration of hundreds of thousands of Chinese and natives of India into South and East Africa (especially into the Transvaal and Natal), into Siam, Malaya, the Dutch East Indies, Burma, Ceylon, and the West Indies. Thousands of other Asiatics subsequently left Asia for the islands of the South Seas, the Americas, and other regions. At the present time, between 16 and 17 million people of Asiatic origin are estimated to be living outside Asia. Of East Indians alone 4,125,000 have migrated beyond the borders of India. They now compose two-thirds of the population of Mauritius, or approximately 150,000; one-half of the population of British Guiana, or approximately 145,000; one-third of the population of Trinidad, or approximately 140,000. In some cases, they are supplanting the natives. For instance, in the Fiji Islands, the East Indians in 1921 numbered 60,000, while the Fijians numbered 84,000. In the subsequent sixteen years, the East Indians increased approximately 29,000, while the Fijians increased only about one-half of this number.

Also incidental to the expansion of Western Europe was the diffusion of European culture over large areas of the world's surface until its often subtle influences have penetrated, to a greater or lesser extent, even the more isolated and remote regions. European artifacts are now commonly found all over the world; for example, the Standard Oil can (because of its manifold uses, a prized possession of many present-day feudal and folk peoples), European rifles, cannon, war-ships, airplanes, automobiles, tractors, cameras, electric lights, cigarettes, rubber goods, and chemicals. European languages are now spoken by millions of people outside Europe. European clothing has, to a greater or lesser extent, supplanted native garb throughout North and South America, the West Indies, Japan, Hawaii, the Philippines, Australia, New Zealand, Turkey, Egypt, India, China, and South Africa. European religions have now crowded out, or are in serious competition with, the native religions of the Americas, Africa, Australia, New Zealand, the South Sea Islands, China, and

India. European ideas, attitudes, sentiments, points of view, and philosophies of life have been widely diffused by such human agencies as missionaries, traders, soldiers, sailors, colonial administrators, scientists, and tourists; by indirect means, like radio broadcasts, newspapers, magazines, and books; as well as by those native men and women who, subsequent to a period of study in Europe, have returned to their native lands to become powerful centers of European diffusion.

But probably the most significant of all the events connected with the expansion of western Europe, at least so far as its actual contribution to this expansion is concerned, has been the development of a world-wide economic order. This world-wide economic order, based upon European manufactures and the persistent exploitation of natural resources in all parts of the world in order to provide the necessary raw materials, has involved the operations of a vast commercial fleet to carry raw materials to Europe and to distribute, in turn, European articles of manufacture over all the outlying areas.

The export from Europe of capital and machinery marked the final phase of the entire expansion process. It marked the final phase because this export of capital and machinery resulted in the development of manufacturing centers in outlying areas, particularly in India, China, South Africa, South America, and in other places where local production is now coming seriously into competition with European manufactures. This increasing competition for local markets has been intensified in recent years by the counterexpansion of Japan, whose people, accepting those elements of European culture which were advantageous to them and discarding all else, seriously entered the markets of the world, at an enormous disadvantage to Europe. All this has led to increasingly severe competition between European nations for constantly shrinking markets, and has contributed in no small way to declining profits, to "frozen" credits, financial crises, depressions, and wars.

Since this competition, in all likelihood, will not grow less in the future but, on the contrary, will probably increase, European economic domination of the world is now apparently at, or near, an end. European ecological expansion began to diminish early in the present century, and the settlement abroad of great numbers of Europeans practically ceased two decades ago. The political domination of Europe also appears to be suffering serious strain with the rise of nationalism all along the line of European advance—in India, Egypt, Turkey, Morocco, China, and South Africa. Even if Germany, with her recent remarkable military development, should be able to reshuffle European political control, it is doubtful if she could long stem the rising tide of nationalism, particularly in Asia, any more effectively than could Great Britain, France, or any other imperial power. Only the cultural expansion of Europe, proceeding as it does by more subtle means, appears to be likely to continue indefinitely in the future.

I have sketched the expansion of Europe in some detail in order to suggest a fruitful frame of reference for the study of the contact of races in the New World. The expansion of Europe is a distinct historical process. It constitutes an era of world history which had a definite beginning and which, as careful observers of the present scene are pointing out, is now at, or near, an end. It has, therefore, a unitary character which makes it a *thing* like any other natural object and consequently subject not only to study in terms of itself but also to comparison with other instances of the same type; subject to comparison, for example, with the Greek and Roman expansions in the ancient world, with the so-called "barbarian" invasions of the Roman Empire, the Arab migrations across north Africa and into the Iberian peninsula, and the Mohammedan expansion into northern India.

Not only is the expansion of Europe, as a unit, comparable to other cases of expansion, but the varying circumstances and conditions under which it proceeded in different parts of the world and at different periods of time, together with the varying series of consequences thus elicited, are themselves capable of comparison and, hence, of yielding a body of general data.

The coming together in Brazil of Europeans and native Indians and the subsequent importation of Africans were incidents of

this expansion, as similarly was the coming into contact of Europeans and native Indians in the United States and the subsequent importation of large numbers of Africans into that country. Since the cultural consequences of these contacts differed, as well as the conditions and circumstances under which they took place, a detailed study of these variations may conceivably throw significant light upon the precise nature of the cultural processes involved and upon the ways in which, under given circumstances, they operate.

One incident extensively connected with the expansion of Europe was the development of a plantation system in several different regions of exploitation. For instance, in recent years, huge rubber plantations have appeared in Sumatra, the Malay peninsula, East and West Africa, and in regions of the New World. During the 16th, 17th, and 18th centuries, sugar plantations flourished on several islands of the West Indies. During the 17th, 18th, and the first half of the 19th centuries, in particular, huge cotton and tobacco plantations dotted the southern parts of the United States. During the 16th and 17th centuries there developed in Brazil, particularly at Bahia and Pernambuco, one of the world's first great centers of sugar cane production, where a planter aristocracy grew rich furnishing sugar for the tables of Europe. This commerce eventually became so extensive that sugar, which previous to its cultivation in Brazil had been rare in Europe, became a common article of European commerce. In 1800, an English smuggler, Thomas Lindley, imprisoned at Bahia, looked out over the shipping in the harbor, and wrote, "a degree of wealth, unknown in Europe."

The development of these 16th, 17th, 18th, and 19th century plantations in Brazil, the West Indies, and the United States created an ever-increasing demand for cheap labor and eventually led to the importation of African slaves on a huge scale. It is estimated that from 1680 to 1786, 2,130,000 Africans were brought into the West Indies and the United States. Hispaniola alone is said to have received 1,000,000 during the entire slave period. Since, following emancipation in 1888, all official records of the Brazilian slave trade were destroyed, the number of Africans imported into this part of the New World probably never will be known with any exactitude but it was, in all probability, greater than the number imported into either the West Indies or the United States. Although the slave trade was presumably abolished in Brazil in 1831, it is estimated that during the quarter century from 1825 to 1850, 1,350,000 Africans were disembarked in her ports.

The subsequent careers of these imported Africans varied with place and with the circumstances and conditions of contact and subsequent racial experience. It is for this reason that the exhaustive study of the circumstances and conditions surrounding each case of contact, and the subsequent comparison and contrast of cases, conceivably may throw significant light upon the problems, practical as well as theoretical, growing out of race contact, problems which, with increasing speed of communication and the consequent shrinking of the earth's surface, are coming each year to be more and more acute. As an important part of this extensive study, we may set down here the more significant facts regarding the career of the African in Brazil. Unfortunately, it is possible to cite here only the general outline of this career. Those who are interested in the detailed investigation upon which these generalizations are based will find considerable information in the writer's book, *Negroes in Brazil. A Study of Race Contact at Bahia,* (University of Chicago Press, 1942).

Of particular significance is the fact that, although probably more Africans were imported into Brazil than into any other region of the New World, the Negro, like the Brazilian Indian before him, is apparently disappearing as a racial unit. The general tendency throughout Brazilian history seems to have been to absorb, gradually but inevitably, all ethnic minorities into the predominately European stock.

It is true that the mixed-bloods are increasing, but their increase appears to be at the expense of the African and not of the European. Nor is there growing up in Brazil a relatively permanent mixed racial stock, like the Macanese in China, the Goanese in India, or the "Cape Coloured" in South Africa.

Instead, the mixed-bloods appear to be gradually absorbing the blacks, while they themselves are increasingly being incorporated into the predominately European stock.

In the development of this general tendency to amalgamate and to assimilate all ethnic minorities, the circumstances and conditions of colonial settlement played a significant role. In Brazil, unlike the United States, few European women emigrated during the first years of colonization. Until stable living conditions and a normal distribution of the sexes were achieved, the cohabitation of Portuguese men with native Indian women commonly took place. In this way there was assured a population large enough to colonize successfully the new frontier, in spite of the fact that the mother country, Portugal, was unable to provide it by reason of the drain upon her slender population resources to conquer and to maintain the Empire in Africa and the East Indies. When Thomé de Souza, in 1549, established the first permanent settlement at Bahia, he found on and about the Bay of All Saints on which the city was built a large number of mixed-blood descendants of Portuguese sailors and adventurers who for some years had been living with the Indians. Many of Thomé de Souza's men took mates from among these mixed-bloods; others cohabited with pure Indian women. These interracial unions, as in Goa and elsewhere throughout the Portuguese dominions in the East, were subsequently encouraged as a matter of policy by the Portuguese state, and the Catholic Church, as Gilberto Freyre in *Casa grande e senzala* puts it, "regularized them into Christian marriage," thereby lending religious sanction to interracial crossing and bringing parents and children within the control and discipline of the Church. Thus, there gradually grew up and became firmly fixed in the mores of colonial Brazil a tradition of intermarriage.

This case of racial intermarriage during the precarious days of settlement is not unique in the history of European expansion. In fact, in those instances in which the sex ratio was out of balance, it seems to have been universal. The settlement of the United States, at least in large part, was not one of these cases. But the settlement of South Africa by the Dutch, and of India by the English, were accomplished under similar circumstances. In both of these cases, the mixed-bloods were at first accorded the treatment and the career usually accorded the progeny of fathers whose normal parental sentiments do not run counter to caste sentiments laid down in the mores. On this frontier, as on all frontiers, a new society was emerging, and the mores which grew up and crystallized into fixed and relatively permanent customs were the result of the unwitting and unplanned responses of human beings to the needs of their time and place.

Miscegenation, particularly when linked with intermarriage, resulted in bonds of sentiment between parents and offspring which hindered the arising of attitudes of race prejudice and at the same time placed the mixed-bloods in a favorable position for social advancement. With rise in class, intermarriage between whites and mixed-bloods, especially those of the lighter shades, became increasingly common.

Thus, endogamy has for some time been breaking down in Brazil, particularly along the biological borders of the races and, with the continued rise of individuals from the inferior status group, this tendency is evidently increasing. It is true that color and negroid features are still symbolic of slave origin, and that these racial marks still tend to be closely identified with low status, and to constitute for this reason an obstacle to marriage into the upper classes. But these symbols tend to lose their restraining character not only in proportion to the degree white intermixture increases, but also, and more importantly, in proportion to the degree their traditional meaning is called into question, in the case of a given individual, by evidences of other qualities associated with status in the upper levels of society.

One should point out in this connection that, in general, slavery in Brazil, as also to a considerable extent in the United States, was characterized by the development of increasingly intimate primary relations between master and slave, and that the resultant personal attachments inevitably tended to humanize the institution of slavery and to undermine its formal character. Thus, Brazilian slave society became organized, to

a considerable extent, on a familial and personal basis. The custom of manumission became firmly intrenched in the mores, constituting, at least under certain circumstances, universally expected behavior. Brazilian Negroes were thus released from a servile status *gradually* and under circumstances which favored the continuance of intimate personal ties already built up.

Moreover, emancipation sentiment in Brazil never suffered from a wave of fear like that which swept over our South after the Negro uprising in Haiti and the disorders attendant on the subsequent annihilation of the Haitian whites. Neither was it limited to any one section of Brazil, but on the contrary penetrated every community. Even in Bahia, where the institution of slavery was apparently very firmly rooted, individuals and organizations possessing prestige in the eyes of the community, and including a considerable portion of the press, took up the slaves' cause. Thus, the "struggle for consistency" in the Brazilian mores between the ideas associated with slavery, on the one hand, and the ideas disseminated by the Church, the French Revolution, and the abolitionists, on the other, went on *inside* each local community where it had in its favor the intimate and personal relations of individuals who not only lived in close proximity to each other but also were bound together by intimate ties of family, religion, and friendship. Final emancipation came about as the culmination of a widespread liberation movement which for years had dominated the public mind. Thus, the release of the last slaves in bondage did not, as in the United States, occur as an incident of civil war; nor was the pattern of race relations which had grown up and taken form during slavery ever submitted to the strain of a social upheaval following a crushing military defeat and the imposition of policies of "reconstruction" from without.

Thus, the Brazilian white has never at any time felt that the black or the mixed-blood offered any serious threat to his own status. No feelings of fear, distrust, apprehension, dread, resentment, or envy, have been stirred up, as in the South during and following the Civil War, no sense of unwarranted aggressions or attacks. It is probably for these reasons that race prejudice, as it is understood in the United States, does not exist in Brazil. For race prejudice appears to be a function of a racial situation in which a dominant race senses, either consciously or unconsciously, a threat to its status.

In general, the present economic status of the Brazilian Negro, at least as I have intimately known him in Bahia, is not greatly dissimilar to that of the North American Negro. Either pure or mixed with the white, the Brazilian Negro is represented to some extent throughout the entire occupational scale. However, as one might expect, considering his original slave status, his relatively disadvantaged position upon receiving his freedom, and the comparatively brief time he has been able to compete on more or less equal terms with the white, the Brazilian Negro is still concentrated in the low-pay, low-status employments.

It is possible that the Brazilian blacks and mixed-bloods, lacking as they do in most cases the profound sense of inferiority which has long been characteristic of the Negro in the United States, particularly of the mixed-bloods, have been less activated by personal ambition and consequently have not perhaps, *as a group,* risen in class as rapidly as has the Negro in the United States. Feeling themselves less under the necessity of demonstrating to a hostile white world their individual talents and abilities, they have not been driven by the same powerful incentive for social advancement.

But it is exceedingly important to note that this rise in class on the part of the Brazilian blacks and mixed-bloods, when it does occur, is recognized not merely inside the Negro world, as is largely the case in the United States, but by *virtually all* members of the Brazilian community.

In Brazil, there is no deliberate segregation as one ordinarily finds where races have been embittered for a long time; residential distribution of the racial elements is largely the consequence of economic sifting. Such isolation as does exist is in large part due to differences in economic and educational level, or to the Negro's identification with African cultural survivals, particularly the fetish cult. For the assimilation of the *Africanos,* particularly in the five principal centers of

Negro concentration—Bahia, Recife, Maranhão, Rio de Janeiro, and the interior of Minas Gerais—while now far advanced, is not yet complete. African cultural elements still persist, particularly the attitudes, sentiments, and ideas associated with religious practices, thus setting apart to some extent a portion of the black population.

Lynching and the rape of white women by colored men are unknown, "passing" is unnecessary, and circumstances are not ordinarily conducive to the appearance of the personality known as the "marginal man."

Since, then, the blacks, the mixed-bloods, and the whites do not constitute endogamous occupational groupings, the social structure in Brazil is not that of caste. Nor does the Negro in Brazil appear to be, as he is in the United States, developing into a highly self-conscious racial minority in free association with, but not accepted by, a dominant racial majority. Instead, the entire organization of society tends to take the form of a freely competitive order in which individuals find their social position on the basis of personal competence, individual achievement, and fortuitous accident, rather than on the basis of racial descent, a fact which is perhaps best reflected in the saying commonly heard at Bahia, "A rich Negro is a white man, and a poor white man is a Negro."

The Brazilian racial situation is, then, sufficiently distinct from those racial situations in many parts of the world where a national or racial minority, like the European Jew, or the North American Negro, for example, is in free association with, but not accepted by, a dominant national or racial majority, and from the racial situation of India, where the social order is entirely organized on the principle of caste, to constitute, along with perhaps the Hawaiian racial situation and certain others, *a distinct type* namely, a multi-racial class society.

Although Brazil seems never to have had a *formal* racial policy, the traditional behavior which grew up under the influence of immediate and unreflecting responses to the conditions and circumstances of colonial life gave rise to an *informal* racial policy, or racial ideology, which underlies and gives consistency to the mores, and appears in active consciousness only when the mores are questioned from without and individuals seek to make reasonable and to defend their customary conduct. This ideology is perhaps best summarized in the phrase commonly heard at Bahia, "We Brazilians are becoming *one* people."

Thus the race problem in Brazil (in so far as there can be said to be a race problem) is in large measure identified with the resistance which an ethnic group offers, or is believed to offer, to eventual absorption into the predominantly European stock.

This does not mean that there are no social distinctions in Brazil. Neither does it mean that there is no discrimination, that whites freely accept Negroes in marriage, or that the Negro's conception of his role is in all cases identical with his status. Prejudice exists in all parts of Brazil. But, with the possible exception of certain areas of the south, where the arrival in comparatively recent years of numbers of immigrant peoples with alien attitudes and sentiments has perhaps modified to some extent the original Brazilian mores, it is *class*, rather than *race*, prejudice. It is the kind of prejudice which one finds *inside* the ranks of the Negro in the United States. The significant fact remains that wherever the original Brazilian mores prevail, a man of color not only may, by reason of individual ability, personal competence, or favorable circumstance, improve his status, but also enjoy recognition of this achievement on the part of white members of the community as well as black.

# THE UNITED FRONT

By HARRISON HALE

The year 1943 marked the bicentennial of the birth of both Antoine Laurent Lavoisier (August 26), Frenchman and Father of Modern Chemistry, and Thomas Jefferson (April 13), author of the American Declaration of Independence. A friend and contemporary of these distinguished men was Pierre Samuel du Pont de Nemours, a Frenchman who later became an American and exerted a lasting influence upon the history and industry of our country. These three, Lavoisier, Jefferson, and du Pont, may be considered as symbols of our science, government, and industry; their cooperation presented a United Front for the advancement of civilization and the welfare of mankind.

As Jefferson was a statesman, vitally interested in science, so Lavoisier was a scientist who gave much of his time and effort to serving his country, only to lose his life by the guillotine during the troublous days of the French revolution. Lavoisier, too, was well-to-do and trained as a lawyer, but was also a scientist. He did not practice law, for he loved science and at the age of twenty-three won a medal for a paper on the best method of lighting the streets of Paris. His accuracy led him to doubt the Theory of Phlogiston, especially since the use of the balance showed a gain in weight in burning rather than a loss when the products were collected. The theory stated that phlogiston was given off when a material burned. He felt sure something must be taken up in burning and so when Priestley discovered oxygen on August 1, 1774, Lavoisier, before reaching his thirty-first birthday, interpreted the discovery, named the new gas, and soon became the master mind among the chemists of his day. His study of the elements and his clearly written textbook not only won the support of the chemists of the time but entitled him to be called the Father of Modern Chemistry. Priestley's discovery which Lavoisier interpreted marks the beginning of modern chemistry—at almost the same time as the birth of the American Republic.

Lavoisier served on countless boards for the advancement of the welfare of the people of France, and used his scientific knowledge to give his country the best gunpowder then known.

Since Thomas Jefferson was born April 13, 1743, he was only thirty-three when he wrote what is declared by Chinard to be "not only a historical document," but "the first and to this day the most outstanding monument in American literature." That so young a man, born and raised on the frontier of the Colony of Virginia, could have done this indicates not only innate ability of a high order, but also well-directed study and rigorous training. The fact that he spent two years at the College of William and Mary and was at home not only in Latin and Greek but also in several modern languages is not so much of an explanation as that made by his biographer in the *Encyclopaedia Britannica,* "Industry and scholarship were the secret of his success." He "disciplined himself to habits of study."

His background was good; his father, Peter, was forceful and well-to-do, though not rich, and his mother, Jane Randolph, was from one of the most distinguished families in the Province. But he knew more than languages. He knew enough of higher mathematics that "throughout life he made practical use of the calculus." As he himself said, "Nature intended him for the tranquil pursuits of science, in which he found infinite delight," and to which he longed to return.

But there were so many demands upon young Tom Jefferson that science could only share his attention and contribute to make him a well-rounded, vigorous, efficient man without whom our country would not have existed just as it does today. Many states are in the area acquired by the Louisiana Purchase, for which Jefferson was responsible. He was "notable for his efforts to secure scientific exactitude." His knowledge was broad and included many fields. Admitted to the bar at twenty-three, he became

a successful lawyer but did not practice long, for he had to look after his thousands of broad acres with more than one hundred slaves. He designed a more efficient plow, understood mapmaking, and knew something of paleontology, ethnology, and botany. He is recognized as the Father of our National Architecture. For eighteen years he served as President of the American Philosophical Society with headquarters at Philadelphia.

Jefferson served as a member of the Continental Congress, the Virginia legislature, Minister to France, Governor of Virginia, was the first Secretary of State, the second Vice-President, and the first President to be inaugurated in Washington. He lived for fifty years to a day after the signing of the Declaration of Independence.

He was a great democrat, believing in the people and their judgment when based on education. "He formulated as perhaps no other American of his generation, an educational policy for a democratic state."

Jefferson, as Minister to France, and Lavoisier were both friends of Pierre Samuel du Pont de Nemours, only four or five years their senior. Du Pont was a man of energy and influence, loyal to the King and appointed to numerous positions of honor and service. Jefferson considered du Pont the leading man of France. Of Lavoisier, du Pont said, "I have never known a man more willing to sacrifice fortune for friendship or the public weal."

In 1787, two years before Lavoisier's great *La Traité de la Élémentaire Chimie* was published, sixteen-year-old Eleuthère Irénée du Pont, son of Pierre Samuel, began work at the Arsenal under Lavoisier and remained there for nearly five years until Lavoisier was transferred to the Treasury.

Darker years followed; Lavoisier was executed for no real reason, both Pierre and Irénée du Pont were arrested, their printing business was ransacked and their lives were in danger. Then the father decided that the family should move to the land of promise, America, where Victor, Irénée's older brother, had already gone.

After a voyage of ninety-one days the du Pont party of seven adults and six children reached Newport, Rhode Island, on New Year's Day, 1800. Many ambitious plans of the senior du Pont did not prove practical. Then after nearly a year Irénée went hunting one day with a French-born, American artillery officer. The hunting was good and soon the ammunition was gone. In buying more the quality was found to be poor, although the price was high. This gave an idea which sent young du Pont back to France to seek financial support for his venture and machinery for his powder mill. Successful in his efforts, he was back in America by July. A site had to be chosen. After due consideration the Broom farm, four miles west of Wilmington on the Brandywine, was selected. The willows growing in this vicinity, which would make excellent charcoal for black powder, are said to have been one factor in the decision. E. I. du Pont, his wife and three children made the crude stone farmhouse their home. Not far away the powder plant was built. At first this was called Lavoisier Mills by Irénée because they "would never have been started but for his kindness to me."

The skill and energy of the founder made the mills successful, furnishing powder of fine quality. Jefferson, then President of the United States, recommended that powder should be bought from du Pont. In the War of 1812 and in every other war of this country since that time, the du Pont Company has been a chief source of munitions.

Resting on the principles clearly set forth by Lavoisier, the science of chemistry has steadily grown in breadth and importance. United with the skill, business ability, and forcefulness represented by du Pont, it has produced an industry bringing countless products for the benefit of all men.

In 1816 Jefferson wrote the following to du Pont senior, who had returned to France: "Enlighten the people generally and tyranny and oppression of both mind and body will vanish like evil spirits at the dawn of day."

This generation faces a crisis in the world's history and an unparalleled opportunity. To meet it we need the United Front given by the ability and vision of broad-minded, liberty-loving statesmen, such as Jefferson, the scientific spirit of accuracy shown by Lavoisier, and the efficiency and resourceful daring of businessmen like E. I. du Pont. And these must be supported by intelligent men and women everywhere.

# THE NEW HENRY GEORGE

By G. R. DAVIES

WHILE we are not at all likely to accept the totalitarian philosophy, the experience of Russia may nevertheless serve to teach us a lesson in theoretical economics. It is a lesson which has been pointed out before, but which has never been regarded as important. Of all our economists, perhaps Henry George came the nearest to suggesting it, but he failed to see its full implications.

When the Russians adopted modern cost accounting methods for their ambitious corporate system, they made the simple discovery that the cost of human services—wages of management and labor—by no means equaled the value of produced income. If, however, all items of capital equipment, such as real estate and machines, were accorded their imputed earnings, then accounts balanced. In other words, as we well know from our own experience, the cost of production, in the broad meaning of the term, is represented by the earnings of capital and labor. Theoretically, in perfect equilibrium markets, a unit of labor, land, and machinery each gets the value it adds to total production.

But this matter of costs is only preliminary to the essential point of the discovery. Conventional economics has always assumed that private earnings may be broadly classified as payments for personal services and payments for saving. To us, payments for saving are as necessary and as justifiable as payments for services. It is the theoretical aspect of this conclusion that the Russian experience questions.

If a corporate system could start its books, as the Russian system did, without the usual credits to owners of private capital, it would absorb the earnings which we call interest, dividends, and the "unearned" portion of profits. It then would have ample savings without paying for saving. However, if it began in conformity with free enterprise, and built its corporate structure by crediting investors, then its capital earnings would eventually go to investors, even though temporarily plowed back. And it would be obliged to hold out the attractions of interest or dividends to insure further investment. Practically speaking, a system thus established could not be materially changed.

Just what percentage of total production is theoretically allocated as capital earnings we do not know. Undoubtedly it varies from one country to another, and from one stage of development to another. Moreover, it could be modified by withholdings or bonuses. But on the basis of markets as indicated by our own experience, such earnings probably would have approximated 30 percent in the early days and 25 percent in recent times, while normal savings shortly before the Great Depression were estimated at 20 percent. If these estimates are correct, collectively we have been paying investors 25 percent of our aggregate income to induce them to save 20 percent of it. But the high cost of saving guarantees relatively free competition, and prizes for the winners. On farms and in highly competitive small businesses these prizes may be small. But unearned increments and monopolistic profits should round out the aggregate payments for saving.

The principle involved in capital earnings has an interesting relation to the theories of Henry George and the so-called single tax. Henry George argued that the earnings of land represent in effect a tax which individuals levy upon society, and which should be recovered by the single tax. But he failed to note that the original earnings of land provided funds for the early stages of capital investment. And these investments in turn, combined with land rent, supplied later capital. Consequently it may plausibly be argued that in the aggregate practically all capital earnings are theoretical derivatives of land rent, though over the years individuals may have confused the issue by buying and selling the properties which yield these earnings. Capital, therefore, may be said to possess an effective taxing power. Its levies may be called a natural tax, because they arise naturally from an equilibrium

market. Obviously this natural tax could not now be recovered by an enlarged single tax without destroying free enterprise. Moreover, the taxing power of capital may be defended on grounds of expediency. But at least it emphasizes the truth of the traditional religious principle that wealth is a trust fund.

The fact of capital's natural tax helps to explain some of the phenomena of history. In a new country free enterprise doubtless stimulates a rapid rate of progress, inasmuch as it offers large bonuses to successful tycoons. But as the country matures and wealth settles in the hands of an hereditary class, the incentive to take risks lessens. As markets become complex, as inherited capital loses its initial spirit of enterprise, as diminishing investment returns are experienced, and as depressions become common and extreme, free enterprise systems tend to pass over into plutocracies, dictatorships, or militaristic empires.

The earliest records of civilization, written on the clay tablets discovered by archeologists in the Tigris-Euphrates Valley, reveal free enterprise in full bloom. But various retarding factors, such as those just mentioned, produced rebellions, wars, and empires. Then progress slackened.

Through the centuries of economic history, free enterprise has been revived again and again in frontier areas, or in old areas by the influence of improved transportation. And in each new frontier, as a rule, business has climbed to higher levels of invention and power, and has often revived old reactionary centers. Now that we are shedding our isolationism, new geographic frontiers should keep us busy for a generation or two, assuming the usual clashing of rival imperialisms. After that, only the frontiers of new science will remain. But these frontiers so quickly yield enlarged investment funds, that a paralysis of enterprise may again ensue.

If modern democracies are to escape the historical fate of free enterprise systems, there must be an advance in social science comparable to that which has occurred in the natural sciences.

## SOIL ACIDITY—A NUTRIENT DEFICIENCY

SOIL acidity has long been considered a dangerous soil condition for plant growth. This accusation has resulted, however, as recent researches show, because of fallacious deductions from correct observations rather than from experimental establishment of the fact.

When the application of lime as calcium carbonate or oxide reduced the degree of soil acidity and simultaneously improved the growth of plants, this observation led to the belief that the one of these two concomitant phenomena was the cause of the other. It was this common fallacy of logic, namely that of ascribing causal connection between contemporaneous manifestations, that has for years been responsible for the conclusion that soil acidity *per se* is dangerous. It has also led to the persistence of the equally erroneous corollary that soil neutrality must be beneficial.

Research studies in the Department of Soils, College of Agriculture, University of Missouri, show that soil acidity *per se* is not injurious to plant growth within the limits of degrees of acidity common in soils. When the clay fraction of the soil takes on hydrogen to give acidity other elements of positive electrical charge but of nutrient value are given off. It is then the deficiency of nutrients, or plant starvation, that is detrimental to the crop when the soil becomes acid. It is the exit of the nutrient elements rather than the advent of the acidity in the form of hydrogen ions that is the cause. Liming is beneficial because it applies calcium, which is a plant nutrient, rather than because its carbonate neutralizes the acidity.

These facts have been demonstrated by using carbonate compounds of elements other than calcium, particularly of sodium, a non-nutrient for plants. Neutralization of the soil acidity by the carbonate of sodium is not as beneficial as is the application of calcium carbonate. This demonstrated the fallacy in ascribing the beneficial effects of applied limestone to its acid-neutralizing property. That it is calcium that exerts the beneficial effect has been demonstrated by fertilizing plants on acid soils with calcium compounds that do not neutralize acidity; for example, with calcium chloride and calcium sulfate. These were beneficial to the crop growth even though there was no reduction in the degree of acidity of the soil. Consequently, the addition of the calcium and not the reduction in the degree of soil acidity is the beneficial factor in liming.

It has also been demonstrated that crop growth creates significant degrees of acidity by its removal of the nutrient elements or ions from the clay. The plant's contribution of hydrogen to the clay and the removal by consumption of other positively charged elements replaced by the hydrogen as an exchange was the action making the soil acid. Removal of nutrients from the soil either by plants or by leaching waters brings on the acidity of the soil. We have been focusing attention on the entrance of the hydrogen to the disregard of the loss from the soil of the many plant nutrients that are exchanged in letting the hydrogen take their place.

Furthermore, soil acidity, or hydrogen in the soil, is beneficial in moving nutrients into the plants. Spinach was grown with constant soil conditions as to nutrient supplies, but in one crop series the reaction of the soil was acid while in another it was neutral. Chemical analyses of the crop showed the spinach grown on the acid soil to be well supplied with the soil-borne calcium and magnesium. Analyses were not made for all the elements. The crop had less oxalate than that required to make all the calcium and magnesium insoluble or indigestible. The spinach grown on the fertile acid soil was a deliverer of good concentrations of these two mineral nutrients.

The spinach crop grown on the fertile neutral soil was quite the opposite. The concentrations of calcium and magnesium in this vegetable were much lower. The oxalate concentration was so high that it would make insoluble, not only all the calcium and magnesium in these greens, but also additional calcium in other foods that might be mixed with the spinach in the stomach.

Research has thus clearly demonstrated that the natural acid condition of the soil is largely a case of nutrient deficiencies. It has also demonstrated a more efficient use by the crop of the applied nutrients when such applications allow the soil to remain acid. Much remains to be worked out about the relation of soil reaction to plant nutrition, now that we can approach the task in terms of these newer experimental facts.

WM. A. ALBRECHT

## STANDARDS

IF materials for industry and finished products for consumers were permitted to vary without restriction in design, size, and quality, life would become markedly more complicated, unsatisfactory, and expensive, and our standard of living would fall. Consequently both industry and large buyers have increasingly developed standards and specifications for the goods they make and buy. L. F. Adams and P. L. Alger in *Industrial Standardization* have defined standards as "accurately defined processes, sizes, qualities, and tests of materials and equipment that have been generally agreed upon by makers, users, and the public as proper and desirable for general use." Such standards, they believe, have four distinct values:

*They educate.* They set forth ideals, or quality goals for the guidance of manufacturers and users alike. They are invaluable to the manufacturer who wishes to enter a new field, and to the naive purchaser who buys a new product.

*They simplify.* They reduce the number of sizes, the variety of processes, the amount of stock, and the paper work that largely account for the overhead costs of making and selling.

*They conserve.* They save the losses of defects, left-over pieces, and inadequate tooling that must accompany odd-lot manufacture, by allowing large-scale production of standard designs. Each step in this direction justifies better tooling, more careful design, and more precise controls, all conserving both time and materials.

*They certify.* They serve as hall-marks of quality of inestimable value to the advertiser who points to proven values, and to the buyer who sees the accredited trade mark, nameplate, or label.

It might be supposed that science does not march with the conservatism of standards but only with the innovations of discovery and invention. But science does play a part in the establishment of standards, particularly of those dealing with performance of products. As an illustration, let us consider liquid household insecticides, which consist of a highly refined kerosene in which certain insecticidal substances are dissolved and which are sold under innumerable trade names.

Not so many years ago the buyer of "bug juice" had no assurance that Better Bug Bane, to coin a name, consisted of anything more potent than perfumed kerosene. He bought whatever the druggist had for sale and hoped for the best. The National Association of Insecticide and Disinfectant Manufacturers felt uneasy about this situation and set up an Insecticide Scientific Committee to establish standards for reputable manufacturers. Because chemical testing methods were not adequate for evaluating performance, biological tests or assays had to be made against insects. As a result of about ten years of cooperative research on rearing of test insects, test methods, and statistical analysis of results, the NAIDM has adopted a standard of performance for liquid household insecticides against house flies.

Every testing laboratory now uses the "Official Test Insecticide" supplied by the NAIDM as a standard with which to compare the performance of the insecticide to be evaluated. In a prescribed manner and under controlled conditions the Official Test Insecticide is sprayed into a large cubical chamber containing vigorous house flies that are neither too young nor too old. After a ten minute interval, the operator opens the chamber and enters it to pick up and count the flies on the floor, which are dead or paralyzed. Then the whole procedure is repeated on another group of flies, spraying the insecticide to be evaluated. Repeated tests are made of both the standard insecticide and the unknown. Next day the dead flies are counted and the mean mortality caused by the standard and unknown is determined. The NAIDM decided that a salable insecticide should kill on the average as many flies as the standard. Such an insecticide could be labeled Grade B. If the insecticide was potent enough to kill more flies than the standard, it might be labeled Grade A or Grade AA depending on the difference in kill between the standard and unknown. The result of the general adoption of this

standard of performance has been to raise and to level out the quality of most brands of liquid household insecticides. Now if John Doe finds "Grade AA" on a bottle (formerly a can) of Better Bug Bane, he can be reasonably sure that he is getting something for his money.

The story does not end here. The buyer of Better Bug Bane may have bought the product to kill cockroaches or bedbugs instead of house flies. The label says it is good for both; but is it? Will a test on house flies give the answer for other insects? Five years of research sponsored by the NAIDM went into a study of this question. The answer is "no." One insecticide may be best for roaches, another for bedbugs, and still another for house flies. Methods for making comparative tests against roaches and bedbugs were developed and recommendations were made, which may be put into effect after the war. Thus standardization may induce research and be benefited by it.

F.L.C.

## NATURAL RUBBER PROJECTS

WITH the invasion of the Dutch East Indies by the Japanese, the Forest Service of the U. S. Department of Agriculture, largely in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, promptly undertook further search and experiments for natural sources of rubber other than the Hevea tree. Less than six months after the attack on Pearl Harbor nurseries were established in California for planting 21,000 pounds of guayule seed, which was all then available. During the first year 23,470 acres were planted to guayule in California and 831 acres were planted in the other southwestern States. Seven nurseries located in California, Arizona, New Mexico, and Texas, and having a combined area of 3,439 acres will be able to supply the planting requirements of the Rubber Director for the fiscal year July 1, 1943–June 30, 1944.

Surveys of available wild guayule in Mexico and Texas have been completed and harvesting operations of the wild shrub are under way. In addition, surveys are being made to determine the areas in California, Arizona, New Mexico, Texas, and Mexico that have suitable climatic, soil, and moisture conditions for growing guayule successfully. The information provided by these surveys is available to all desiring to make experimental plantings. Technical assistance and nursery stock have been given to several South American countries, seeds for experimental purposes have been supplied to a number of foreign countries, and the Bureaus have carried out cooperative experimental plantings in Mexico.

From native, cultivated guayule shrubs grown in California in 1942 a total of 440 tons of guayule rubber of high quality was extracted. This quantity is enough for many experiments on properties of the rubber obtained, but neither the planting nor the processes of extracting the rubber have yet been on a sufficiently large and varied scale to justify a conjecture regarding guayule as a competitor of the Hevea tree or the recent synthetic processes discussed in the January issue of *The Scientific Monthly.*

It has long been known that the ordinary goldenrod is a source of a natural rubber (of course, different plants produce different rubbers) that might possibly be of commercial interest. Accordingly, the bureaus interested in natural rubbers organized an experimental goldenrod program of 650 acres near Waynesboro and Savannah, Georgia. Contracts covering land preparation and crop cultivation were entered into with owners of the better types of cotton land. The investigations under way include also the adaptation of standard equipment in planting, harvesting, and drying the leaves of goldenrod.

Another possible source of natural rubber is the Russian dandelion (kok-saglyz). It was found in the preliminary experiments carried out in 1942 that the roots of this plant yield about five percent rubber. These results stimulated the planting of 700 acres last year in thirty-five test fields distributed from Oregon to Vermont.

A part of both the goldenrod and the Russian dandelion crop raised last year was harvested at the proper stage for rubber production in order to extract a few tons from each for experimental purposes. The magnitude of the problem of securing natural rubber from plants that can be grown in the United States, and the vigor with which this

problem is being attacked, are indicated by the fact that the Forest Service expended on its Emergency Rubber Projects in the fiscal year ended June 30, 1943, a total of $20,752,-801.—*Digest of part of the report of the Chief of the Forest Service, Lyle F. Watts, for 1943.*

### EXPLORER OF CELESTIAL SPACES

YALE UNIVERSITY was fortunate in having on her staff for more than twenty years two of the most distinguished astronomers of our time, Ernest Brown and Frank Schlesinger. Both were devotees of austere and exacting branches of their science; both enriched them with important new methods and devices; both rose to unquestioned primacy among living workers in their fields. The recent death of the second prompts this account of the work which has given him a lasting place in the annals of his science.

His special field, the astronomy of position, is as much an art as a science. Its main problems—where the heavenly bodies appear to be, where they are, and how they are moving—may be solved in principle by simple geometrical means. Its methods have gradually been perfected until they are accurate to one part in a million or better; but the quest for such precision unveils many unsuspected errors. To distinguish between those arising from the inevitable, but accidental, imperfections of observations and those which can be got rid of only by improving the conditions of observation requires skill in applied mathematics and statistics; to find the causes of the latter demands a thorough study of every detail of the apparatus, including the psychology of the observer; to devise ways of avoiding or correcting them needs also inventive skill; and to organize a program of research so that results of the highest precision can be obtained efficiently and at a minimum cost of labor and money is a matter of engineering and economic management. In all four of these capacities Schlesinger was a master.

His opportunity came in 1903, when the Carnegie Institution sent him to the Yerkes Observatory for photographic observations of stellar parallax—in plain English, to measure the distances of the stars. The primary need here is to measure the position in the heavens of the selected parallax star, with reference to fainter reference stars in the background, and with all possible precision. Visual observations with the heliometer were more precise than by any other method then known, but they were extremely laborious. About the year 1900 it became evident that still more precise observations could be made by photography.

The gelatine film of an ordinary plate sticks to the glass with amazing tenacity, so that measures of good star images are reliable to 1/10,000 of an inch or better. To reap the benefit of this accuracy, many precautions are necessary in the taking, in the measurement, and in the reduction calculations. Schlesinger's methods set the standards which have been, and still are, employed in thousands of parallax determinations at many observatories during the past thirty-five years. No substantial improvements upon them have yet been devised.

Some of these methods were of his own invention. For example, if the plate is exposed long enough to get good images of the faint reference stars, that of a bright star will be too over-exposed and fuzzy to measure. Schlesinger cured this by mounting above the plate a small metal disk with an adjustable open sector, which was spun rapidly. This cut off the light of the bright star except for a series of short flashes. This series of snap-shots produced a star image which, with proper adjustment of the sector, was as small and sharp as the images of the other stars, and proved to be as accurately measurable. This simple device has enabled the observation of thousands of naked-eye stars, even the brightest.

The measures on the plates have to be reduced to a common standard. This was formerly done by calculating a correction formula for each plate, and then applying it to the parallax star. Schlesinger showed by simple algebra that the desired result could be obtained directly by taking the differences between the measured position of each reference star on the plate from the standard and averaging them in a particular way with the aid of factors called "dependences." With fifteen or twenty plates to work up, this saved a great deal of time.

In 1905 Schlesinger was called to the direc-

torship of the Allegheny Observatory, and took an active part in its reorganization. Generous aid was provided by the people of Pittsburgh and the vicinity, the Observatory was moved to a new and favorable site, and a great telescope was installed. At such a time, it was even truer than usual that the primary need of an observatory is a first-class director. Schlesinger's peculiar gifts came into full play—his foresight and sound judgment in choosing fields of work, and his grasp of their essential requirements both in instruments and methods. The great refractor was designed exclusively for photographic work, and is still the most powerful existing instrument for its purpose. With this he began an extensive program of observations for stellar parallax, which is still being continued at the Observatory. It was found that the city smoke, though dimming the brightness of the stars, had no ill effect upon the sharpness of their images, and the long series of Allegheny parallaxes, now more than 1500 in number, are of very high accuracy.

One feature of this program illustrates his scientific conscientiousness. The minute and unavoidable errors in even the best observations once in a while make a calculated parallax, which would be small anyhow, come out negative. This is an absurd result. Parallax observers are human, and the temptation is very strong to take a new set of observations on the star in the hope of getting a more reasonable result. To throw away the old value and substitute the new would be scientifically immoral, but Schlesinger realized that even to take the average of the old and new results is not really playing fair. It amounts to correcting those cases in which the errors of observation make the result come out too small and ignoring the equally numerous cases when they make it come out too great; and this vitiates the general average. Therefore Schlesinger left "warts and all" in his list and kept on observing more stars.

Much excellent spectroscopic work was also done at Allegheny by Schlesinger and his associates, and the orbits of many spectroscopic double stars were determined. The formulae which he developed for the precise calculation of these orbits are still in general use. Special mention should be made of his work on the eclipsing binary u Herculis—one of the very first instances in which the actual sizes, masses, and densities of a pair of stars were deduced exclusively from observation. He was the first to point out (in 1909) that when the brighter star of such a pair is going into eclipse the unobscured portion of its disk will, on the average, be moving away from us, owing to its rotation; and contrariwise when it is coming out, an effect that has proved to be of considerable importance.

Turning to less technical matters one may recall the smile with which he used to tell how an unexciting paper, "The Orbit of 25 Serpentis," came from the printer with the title "The Orbit of Twenty-five Serpents"—the most sensational astronomical headline on record!

In 1920 Schlesinger was called to Yale, where he remained as Director of the Observatory for twenty-one years. He found a long-established astrometric tradition, which he continued and expanded in two directions. A photographic refractor of 26 inches aperture was installed at Johannesburg, South Africa. With this instrument the parallaxes of more than 1600 southern stars have been observed, under the direction of Dr. Alden. This major contribution to knowledge has had interesting by-products, including several cases where a star has been found to be in orbital motion about the center of gravity of itself and an invisible companion.

Schlesinger's last contribution in this field—and one of the most valuable to astronomers—is found in his general catalogues of stellar parallaxes, in which the results of all observers are collected, critically examined, corrected for their minute outstanding errors, and combined into mean values. The preparation of such a work demands the highest degree of knowledge of the subject, and impartial critical judgment. Subsequent studies have not only confirmed his conclusion that his catalogued values are, on the average, systematically correct within a thousandth of a second of arc, but have shown that the probable errors assigned to their individual values substantially represent their real accuracy—an achievement almost without precedent. A star having a

parallax of a thousandth of a second of arc is at a distance of about 200,000,000 times the distance from the earth to the sun.

Schlesinger's second main activity at Yale was the planning and preparation of the great photographic catalogues of star positions. Accurate determinations of the apparent places of stars in the heavens could formerly be made only by visual observations with the meridian circle. But such observations are laborious and costly, and it is much more economical, as well as more accurate, to determine a smaller number of reference stars in this way, and then use photographs to fill in the others between them. Here plates covering a large area in the sky have a great advantage. About the same number of stars are required per plate as reference points whether this is large or small; hence the total number of such points needed to cover a given large zone of the heavens varies inversely as the area of the plates.

This raised a set of new problems, for example, to design lenses for wide-angle cameras so that accurately measurable star-images could be secured all over the plate; to extend the methods of reduction so as to take account of many terms which were negligible on small plates and important in large ones; and to devise economical methods for handling the enormous amount of measurement and calculation involved.

Special measuring engines were designed to handle the larger plates with precision, and special and very ingenious methods of reduction were developed.

With the ordinary measuring-engine, the observer looks into an eyepiece, and turns a micrometer screw to set a fine "wire" (spider-thread) on the magnified star-image. Then he draws his eye back, reads the micrometer head, and writes down his result. This demands re-focusing the eyes three times for each measure, and the resulting eye-strain prevents any one from measuring habitually for more than an hour or two per day.

Schlesinger designed a simple optical system attached to the eyepiece, such that an enlarged image of the star-image and wire were projected down on a white surface at the same distance from the observer's eye as the micrometer head and the record-sheet. The number of hours of measurement per day could then be approximately doubled, with no increase of fatigue—and so the worst "bottle-neck" in the whole scheme was widened.

The results were impressive. The nine volumes of Yale Zone Catalogues so far published contain accurate positions of more than 91,000 stars; while catalogues including 55,000 more are in various stages of preparation—an amazing output for a single observatory of moderate resources. The precision of these observations considerably surpasses that of the older catalogues observed by other methods, and the hours of observing and computing-time were very much less.

The economic efficiency, as well as the accuracy, of the Yale Catalogues gave him justifiable satisfaction; yet he generously insisted that the Lick Observatory, at which the meridian observations had been made to determine accurate and up-to-date positions of the reference stars for the first catalogue, had made fully as great a contribution to it as Yale had.

The large plates used for the later series cover so great an area of the sky that enough reference stars may be found among those which have already been accurately observed so that this special collaboration is no longer necessary.

Nineteenth-century observations of reference stars could not be used for determining the positions of other stars, not because the earlier observations were inaccurate, but because the stars themselves had moved in the interval. The Yale Proper Motions, by comparison with the older observations, give accurate values for the motion of many thousands of stars. Only a very small part of the store of information contained in them has yet, in these troublous times, been evaluated. The rest will be Schlesinger's monument.

# BOOK REVIEWS

## THE OLD WORLD ROBIN*

The old saying "good things come in small packages" applies very well to this unprepossessing little book. Students of bird behavior who have been looking forward to the appearance of David Lack's study of the robin may be disappointed with their first impression of it, but they will soon become convinced that any meagerness it may have is in its format and binding and not in its content. In a sense, this work, based on a number of consecutive years of intensive observation of one of the commonest and most popular of European birds, is a European counterpart of Mrs. Nice's study of the song sparrow in this country. Both are very rich in detail, in the sort of factual minutiae that are not elsewhere available; both are characterized by an underlying pattern that serves to give coherence and significance to what would otherwise be merely a mass of unrelated, or at least, uncoordinated items of information. Lack's book is, in addition, much better reading from the literary viewpoint.

To a large extent, Lack's observational data are based on marked, individualized birds, and have therefore a definiteness and precision all too rare in field biology. This, together with the author's inclination to see the problems in the material at all times and to extend his thinking from the limits of his notes on a single species to wider horizons, makes the book stimulating and provocative as well as informative. In his first chapter, Lack outlines his methods of trapping and of individual marking of birds, and describes the aviaries in which he kept some individuals for special observations. Then he proceeds to discuss, with illuminating effect, innumerable topics centering around the main ones of song, fighting, pairing, courtship, reproduction, territory, migration, food, plumage pattern, age, recognition, and tameness. To take, for example, the first of these larger subjects—that of song; we are given some detailed data and stimulating queries on the song period, the individual variation of song, the audible versus the inaudible parts of song, song in relation to territory, female song, song as a preventer of fights, "battle music," singing for mates, singing when alarmed, mimicry, the significance of song in late summer, and the question, "is song inherited or acquired?"

A final chapter, "A Digression Upon Instinct," makes a worthwhile philosophic, retrospective summation of the type of problems dealt with in the earlier chapters. All through the work one is impressed not only with the author's intimate acquaintance with the robin, but also with a wide range of literature immediately bearing on his subject. Literary sources also provide a cultural setting for the reflections of an educated man upon one of his humbler, but much cared for, fellow mortals.

The reader of this review may be cautioned that the robin is not our American thrush, *Turdus migratorius*, but the quite different, much smaller, Old World bird technically designated *Erithacus rubecula*. Bibliographical references are listed by chapters at the back of the book, and there are two indices, one to species of birds, and one to persons mentioned in the text.

Herbert Friedmann

* *The Life of the Robin.* David Lack. 6 illustrations. 200 pp. May, 1943. 7/6d net. H. F. & G. Witherby.

## CANCER RESEARCH REVIEWED*

*The Biochemistry of Malignant Tumors* is a sincere and painstaking attempt to review and to integrate the findings of research in the problems of cancer. The literature for the past twenty-five years is well covered through 1941; 5,000 references are quoted within 950 pages. The title of the book is somewhat a misnomer, for it is actually an annotated bibliography of many phases of cancer research, including fields which can be placed under biochemistry only by very broad definition. A more critical evaluation of many subjects and apparently contradictory individual findings is curtailed by the attempt to make the volume too inclusive,

* *The Biochemistry of Malignant Tumors.* Kurt Stern and Robert Willheim. 951 pp. 1943. $12.00. Reference Press.

as well as by the authors' acknowledged lack of first-hand experience in many of the fields. These and many other criticisms that can be made of the book are recognized in the authors' disarming preface. Most of the ten chapters terminate with brief, conservative summaries in which no attempts are made to introduce or to advocate any cancer theory.

The book will be useful and stimulating to the worker actively engaged in experimental oncology in that it refers to original sources in a multitude of subjects and furnishes general conclusions reached by the authors of the original papers. For the casual reader, however, greater critical evaluation is desirable; for the expert, the material is presented too incompletely to be used without reference to the original reports. Symposia by experts in individual fields would be more informative for the general scientist, and a complete, up-to-date Index Oncologicus is a real need of the workers in cancer research.

It is of interest to indicate some of the general conclusions reached by the authors after the examination of almost 5,000 papers and books written by over 3,000 individuals. One is immediately struck by the lack of definitive generalizations. The reader cannot but wonder at the contradictions and the apparent paucity of conclusions from the large amount of work already performed. In the reviewer's opinion, the great differences in etiologic factors and in the biology of different tumors is so striking that cancer, as Ewing and others have stated, must be considered as a great group of diseases rather than as one entity. Our knowledge about a sufficient number of separate neoplastic diseases has not reached the stage of analysis prerequisite for a coherent synthesis of the information about neoplasia in general. Viewed from this standpoint it is unavoidable that, in any compilation of the information available at present, the real advances in specific lines of investigation and on specific neoplastic diseases be obscured by attempts to formulate conclusions concerning cancer in general.

*The Biochemistry of Malignant Tumors* is the only book of its type available in the English language; it will prove of definite although limited value as an annotated bibliography. Typographical errors are frequent and, considering the price of the book, the format is poor. It is hoped that this work will be a stimulus for further and improved additions to the literature of experimental oncology—a need felt by many of the workers in the field.

MICHAEL B. SHIMKIN

## FIRST AID THAT AIDS*

THERE is now available a modern text on first aid which is truly comprehensive and splendidly maintains that rarely achieved balance of being neither too technical nor too elementary. This is an advanced guide and goes well beyond the majority of previous works on the subject, many of which have had to sacrifice accuracy to remain elementary. The style is lucid, brief, and precise without being dogmatic. The editors have presupposed intelligence and attention on the part of the reader, which is a refreshing attitude in first aid texts.

The book is comprehensive, including all that needs to be known for the wise application of first aid as an emergency measure. Included is a brief consideration of the general principles of first aid, a short discussion of normal human anatomy with emphasis on the functional aspects of structure, the principles of bandaging, the management of various forms of wounds, control of shock and of hemorrhage, the immediate care of burns and frostbite, the problem of transportation of injured persons, discussion of fractures, aid in respiratory emergencies and visceral injuries, head and central nervous system injuries, medical emergencies, and specific consideration of the field problems of gas and bomb air raids. The editors have called upon seventeen of their associates in the various medical specialties at the University of Illinois College of Medicine for chapters dealing with problems within their special fields. Thus, the work is unusually authoritative as well as being more comprehensive in scope than any other previous text in this field seen by the reviewer.

According to the preface, the editors prepared the text primarily for the instruction of medical students. It is also an invaluable

* *First Aid: Surgical and Medical.* Warren H. Cole and Charles B. Puestow. Illustrated. xxiv + 351 pp. 1942. $3.00. D. Appleton-Century Company.

source of practical information for physicians, many of whom are decidedly rusty on questions of first aid. Admittedly, quite a few of the procedures suggested are definitely beyond the scope of non-medical first aid enthusiasts. Far better temporary neglect than over-zealous ill-advised therapy! However, the authors recognize this hazard and repeatedy stress the importance of exact knowledge before attempting to do anything at all. It is their contention that the cure for "a little knowledge is a dangerous thing" lies not in maintaining a state of ignorance but in extending education. In this concept we heartily concur. The more informed an individual is, the more fully aware he is of his limitations. The book, therefore, should not be limited in its usefulness as a textbook for medical students or a refresher volume for physicians; it can, and should, be extensively employed as a text in college courses where first aid, elementary anatomy and physiology should be subjects required of all students. The ignorance of presumably "educated" persons regarding the structures and functions of their own bodies is appalling. This ignorance makes the task of physicians in maintaining health much more difficult than need be.

Splendid and liberal illustrations not only clarify the text so that no confusion of intent is possible, but definitely add much valuable information. In time of peace, the tremendous incidence of accidents makes the knowledge of first aid valuable to all; in time of modern war, with the threat of civilian bombardment always present, training in first aid becomes a civic obligation.

EDWARD J. STIEGLITZ

## MEDICAL SCIENCE*

THIS book represents the product of an ambitious undertaking, namely, a survey of the history of medicine, the etiology, pathogenesis, pathology, diagnosis, and treatment of disease, and a consideration of the field of public health, with all its ramifications. It is designed primarily for the student nurse, but suggested by the authors as of value to the graduate nurse, laboratory technician, social worker, and others in similar fields.

* *Introduction to Medical Science.* Gulli Lindh Muller and Dorothy E. Dawes. Illustrated. 454 pp. 1943. $3.00. W. B. Saunders Company.

In many respects, the book succeeds admirably in its purpose. In general, the chapters on diagnosis of disease are excellent, being comprehensive and clear, as is the discussion of therapy. The section on control and prevention of disease includes summaries of the federal and state health programs, measures for the control of food and water, industrial hazards, and other important public health problems. However, the subjects of bacteriology and immunology are given insufficient attention in this text. All infectious diseases are grouped under a brief consideration of "endogenous toxins" in the chapter on causation of disease. Here, nothing is said about predisposing factors, routes of infection, or the interaction between the same organism and host depending on the site of entry of the former. In the same chapter, allergy is very cursorily treated, and a misleading statement is made in the description of anaphylactic shock, as a "phenomenon related to hypersensitivity, except that it manifests itself as a spasmodic contraction of smooth muscle."

Bacteriological diagnosis is incompletely described, and the differences in procedure depending upon the type of organism, stage of the disease, presence of secondary invaders or normal flora, and other factors, are largely ignored. An example of this is the statement on page 221, "the typhoid-dysentery group of organisms is isolated by culture on Endo's medium, and then identified by macroscopical agglutination in immune sera," which is certainly an over-simplification of a complex method. Similarly, the discussion of therapy by immune sera is inadequate. The subject is not put on a reasonable basis. Further, little is said about dosage, time or route of administration of immune serum as affecting the success of its action. The same criticism may be made of the discussion of serological procedures as an aid in diagnosis; the Wassermann test is outlined as if the reaction were specific, as is the heterophile agglutination test for infectious mononucleosis. There is no good outline of the fundamental bases of antigen-antibody reactions as a preliminary to presentation of their applications. It might be argued that it is not the purpose of this book to discuss applications of bacteriology and im-

munology in detail. It is apparent, however, that chemical and other types of tests are described much more adequately. For example, the colloidal gold test receives a page and a half of explanation, including a chart and color plate.

The book is an undoubted contribution to nursing texts. It would be greatly improved by revision of the sections dealing with bacteriology and immunology to give a more fundamental approach to these subjects. A glossary or explanation of technical terms would be of considerable value.

The illustrations for the most part are excellent. The book is well bound and printed.

MALCOLM H. SOULE

## GENES AND THE MAN*

TAKING as his thesis the concept that man is intelligible only as we perceive what has made him as he is, and that thus genes and chromosomes are important to us only because of the effects they produce during the course of growth and development, the author of this stimulating volume proceeds to trace the sweep of an individual's development and progress from their beginnings in the protoplasm and genes through maturity to decline and death. The welding together into a single connected story of the events of genetics, embryology, and physiology is a laudable though difficult undertaking, but Doctor Glass has made a noteworthy success of it. The book is critical and thorough, and its underlying philosophy may be illustrated by a statement made by the author in connection with the study of mitosis: "We should be on our guard lest we take a very superficial knowledge for real understanding."

The book starts with a readable and understandable account of cells and cell division. Then follows a concentrated chapter on meiosis, mutation, and the basic facts of genetics. The biology and physiology of sex determination are considered in a broad and thorough account. The fourth chapter considers the question of how genes act: the modern concepts of growth and development. Much recent research is cited here and woven into a well-connected story.

A long yet highly condensed chapter traces the embryological development of man. Should the book be used as a text, this chapter especially will require much "teaching." It is an excellent over-view of embryology without, however, much genetics. This is not the fault of the author, of course, and a commendable attempt is made to tie in genetics wherever such knowledge is available.

The last chapter is on growing old. External and internal factors are considered and, as throughout the book, the relative importances and interactions of heredity and environment are carefully assessed.

A few specific points may be mentioned. The book is beautifully illustrated, and on the whole remarkably free from typographical errors, although some do occur. An occasional doubtful statement is met with. On page 158 the author says ". . . more human genes have been detected in the X than in all the rest of the chromosomes combined," a pronouncement with which few students of human heredity would agree. Grey eyes are considered the heterozygote between brown and blue. In discussing the normal distribution curve resulting in the $F_2$ generation from multiple blending factors, the author fails to point out that a similar result would occur if the factors showed dominance.

The book is a highly successful attempt to bring together into an understandable mosaic the too often separated fields of genetics, embryology, physiology, and medicine. The author is to be congratulated.

LAURENCE H. SNYDER

* *Genes and the Man.* Bentley Glass. Illustrated. 386 pp. 1943. $3.50. Teachers College, Columbia University.

# COMMENTS AND CRITICISMS

### War of Words

The new *Scientific Monthly* deserves approval for both the practical and the metaphysical in its content. For example, population problems (Sax) prevent wishful thinking, while mathematical problems (Birkhoff) promote basic thinking. Both approaches seem essential to the solution of imminent human problems. As to population, parthenogenetic pregnancy and hormones in reproductive controls are already suggested by the results of mammalian research as possible in a "new world order." But in any new order "we need more of the scientific method," says Professor Sax, "particularly in the field of social relations and human conduct," as against "abandoning rational thought and reverting to mysticism" in our currently chaotic social evolution. To this end we shall have to resort to metaphysics to overcome the serious lack of synthesis in scientific thought. Technique is not enough.

At present our publications are too much framed by the professional interest of the specialist who jealously guards his "discipline," however trivial. There has thus developed what Peter Carmichael has well called, in his criticism of Irving Langmuir's social philosophy, a "cavalier attitude" toward the controversial metaphysical problems of epistemology by which a scientific synthesis is possible. Science has, indeed, acquired dire and divers delusions of grandeur because of which, in the words of Isaiah Bowman, "the critical spirit is having a hard time." Mathematical theory is so buried in the clouds of the infinite and infinitesimal as to let the so-called "social sciences" erect a Tower of Babel, upon what Thorstein Veblen has satirically called the "hedonistic calculus," and get away with this confusion of tongues by calling it "scientific."

It is here, in the heart of the most acute metaphysical controversy, that science should fearlessly face the problems of politics and religion in seeking truth, not wholly for its own sake, but as that which shall make men *free* in their social relations. Yet there is no *scientific* discipline professionally devoted to such an inclusive synthesis as seems essential if scientists are to escape the just criticism heaped upon them for their grand isolation from social problems. Some publication, where wishful thinking can be overcome in controversy over elemental issues, will have to arise and shine with a beam which will guide us to safe landing in the port of some common denominator. *The Scientific Monthly* has recently by no means avoided such subject matter and it is to be hoped it will open its pages to every possible disputation over the general perspective and orientation of science in its social setting.

In such developments the editors can hardly hope to confine the "experimental section" of the *Monthly* to a few pages of editorial review of "Science on the March." Science is essentially an unfinished business; and a periodical that is read by a professionally diverse clientele is surely such as can best promote progress in synthesis. We would prostitute science to publish a mere heterogeneous compendium of technological information. We cannot keep out of the foxholes of intellectual (moral) disputation if we hope to help in keeping out of the foxholes of war which science has so fearfully implemented.—Alden A. Potter.

### Inflation

I have just read the January issue of *The Scientific Monthly* and when a fellow has done a good job, I want to tell him about it. You and your staff have turned out the best issue that I can recall. I find every article of interest—which is more than I can say of some. Congratulations!—Otto Watts.

### Deflation

Incidentally, I would not have you think that I consider *The Scientific Monthly* an attractively produced journal from the point of view of format. On the other hand, I consider it one of the poorest. What I wanted to say is that its present format is an improvement upon the old. If I may say so I think that one of your principal defects is the paper you use. Now, it would seem to me, would be a good time to change to a more attractive "wartime" paper. But don't let me get involved in re-arranging the format of another journal. I only have one life-time, and I've misspent too much of that already.—M. F. Ashley Montagu.

### Headline and Explanation

I am indeed pleased with the reference to Johns Hopkins University in the January issue of *The Scientific Monthly*. I also find other things of special interest in it. What I do not like is the type used in the title of the magazine. But no doubt you are experimenting with that.—Isaiah Bowman.

Many thanks for your letter of January 5 and the kind remarks you made regarding the contents of *The Scientific Monthly*.

You are the first member of the Association who has objected to the type used on the cover of the *Monthly*. Since the two words *Scientific* and *Monthly* appear to be of equal importance and both of them are rather long, we must either put one above the other or use such type that they can both be on the same line. In advertising I think it is

universally agreed that to have one word above another when they are of equal rank is a bad arrangement. If we put the two words on a line and have type of substantial size, it becomes necessary to use something like the Bodoni which was selected. However much that may fall short of our ideals, I think you will agree that the Table of Contents is now legible without so much trouble as readers had in the old form.—F. R. M.

### Propaganda?

Let me question the propriety of giving space in *The Scientific Monthly* for such matter as the article by Dr. Alonzo E. Taylor of Stanford University discussing the United Nations' Conference on Food and Agriculture. Why was a beneficent conference of learned economists such as Dr. Taylor portrays closed to the press? Why was the right of Senators and Representatives in Congress to be present at its sessions seriously called in question?

That policy of its sponsors justifies the public in concluding that its real purposes were sinister and adverse to American interests. The conference was called by politicians and veiled in secrecy by them. Its agenda were prearranged by politicians and they hid its sessions from the public.

Dr. Taylor discloses no incentive for secrecy. But there obviously was such incentive. Otherwise the sessions would have been open. To picture as beneficent and scientific an international meeting whose sponsors were unwilling for the public to know what it was doing seems inconsistent.

Please do not let *The Scientific Monthly* be made the vehicle of secret political propaganda. To do so will not enhance public confidence in its utterances.—Gilbert O. Nations.

### Sound and Fury

Since your [A. J. Carlson's] election as president of the Association, I have read several of your recent articles, among them your investigation of science in liberal arts colleges as reported in the *Quarterly* of the North Central Association of Colleges and Secondary Schools.

The conditions that your investigation revealed are disquieting. One of your statements attracted my attention: *"It is easier to gather dollars for bricks than to secure pennies for brains."* This statement of fact seems to require different remedies than any you proposed. Consequently I sketch one for your consideration, which has for its purpose very great improvement in teaching of all college subjects at inappreciable financial cost. It sounds as though there were a catch in it, but you know I am not subtle.

The suggestion: Let each college purchase sound recording apparatus and make records of three class sessions of each instructor without his knowledge or the knowledge of the class. Simply let every instructor know that recordings will be made sometime during the year. After the recordings are made, let the instructor hear his records and decide which of the three is most nearly typical of his work. Then have faculty parties from time to time at which the recordings are reproduced, all of them at least once during the year. I rest my reputation as prophet on the prediction that this innovation would very promptly result in a great improvement in teaching.

I wish you would develop this subject into an article for *The Scientific Monthly*. Your active imagination will detect many advantages of the proposal. For example, if an instructor who reads the same lectures year after year should contract the flu, he could rest safely at home while the students could listen without loss to his echo. It suggests possibilities for vacations, etc., etc. I have passed the ball to you; please make a run with it.—F. R. M.

I think you have something in your *suggestion.* I don't know what the cost would be to each college for instruments and personnel capable of running a recording, but I am certain that this method of checking up on ourselves would improve the quality of teaching. I think, however, it should come not from deans and college presidents, but from the faculties as a whole.

Let me give you an experience along this line which shows that even FRM's mind isn't so original after all. Many years ago when a prominent disciple of Freud was on a visit to Chicago propagating the extreme psychoanalysis of 50–150 half-hour sessions with each psychotic patient, with the results and diagnosis, etc., not written up until the end, I raised the question with this doctor, as follows: "How can you possibly remember all the questions you have asked and all the things you have told this patient during this long period of repeated interviews? How will you know that what comes out of the patient's mind at the later interviews was not put there by you in the early interviews? Until this point is settled psychoanalysis will not become a science. Why don't you make a complete record of every interview and by studying these records, we will ultimately know something?" The good doctor shook his head in horror and said, "Those interviews are private and sacred; I would not dream of exposing my patients in the way you suggest."

I think some of our weak brethren in teaching will make similar objections to your suggestion, but I will think about it. I think it is worth thinking about and may be developed. It will, of course, be a shock to many.—A. J. Carlson.

# JAMES McKEEN CATTELL

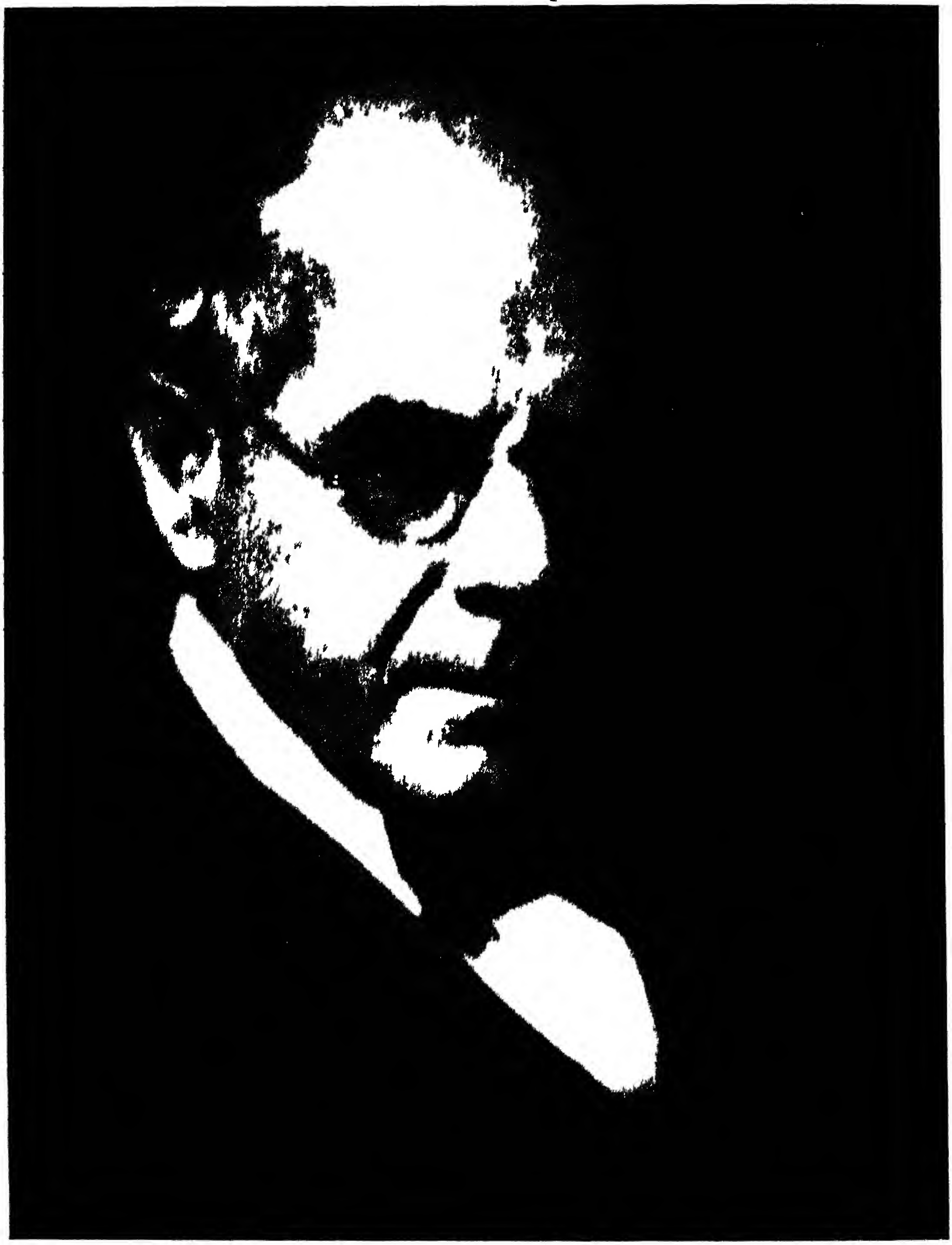
JAMES MCKEEN CATTELL was born at Easton, Pennsylvania, on May 25, 1860, and died at Lancaster, Pennsylvania, on January 20, 1944, in his eighty-fourth year. He began life under favorable conditions and reached maturity at the beginning of a transition period in American science. With singleness of purpose and untiring industry he devoted his whole life to the advancement of science, not only in his own field but in every field. If a comprehensive biography of Cattell were written, it would be in considerable part the story of the organization of American science during his lifetime; and if the history of American science and its organization during the past fifty years were written, it would refer frequently to Cattell's influence upon the period. Such statements can be made so truly of very few American scientists.

Cattell's father was the Reverend William C. Cattell, professor of classical languages in Lafayette College and president of the institution from 1863 to 1883. Consequently Cattell grew up in an atmosphere of culture and intellectual integrity. After his graduation from Lafayette College, in 1880, he went to Europe where he remained for seven years, a large part of the time in the laboratory of Wilhelm Wundt, in Leipzig, where he received his Ph.D. degree in 1886. It was fortunate for psychology in America that Cattell studied in Leipzig in this period when Wundt, then near the zenith of his powers, was making of psychology an experimental science. In 1887 he was appointed lecturer, and a year later professor, in psychology in the University of Pennsylvania, where he promptly established a laboratory and instituted courses in experimental psychology.

In 1891 Cattell accepted a call to Columbia University, where he organized a department of psychology and was executive head, also, of the work in anthropology and philosophy. Columbia promptly assumed leadership among American universities in these fields. Cattell was likewise in charge of psychology in Barnard College and was one of the first professors in Teachers College when it became a part of Columbia University. His academic career closed in 1917 when he was dismissed from Columbia University on the ostensible ground that he committed an act of treason by writing to members of Congress in support of legislation exempting from combatant service in Europe those who had conscientious scruples against engaging in war. Cattell brought legal action against Columbia for libel, but the suit was withdrawn upon the agreement by the University to pay him a substantial annuity.

This difference between Cattell and Columbia University had, of course, an important influence on his life, but it is of interest here primarily because it throws a strong light on one of his characteristics. The difference arose because his conscience and judgment required him to take an unpopular position respecting forcing citizens of the United States to bear arms in foreign lands. In taking this stand he placed his principles above what appeared to be to his advantage and stood by them inflexibly. Without judging of the merits of the particular issue, one can only admire Cattell's unyielding defense of what he believed to be right. It has been charged, perhaps with some justice, that he enjoyed a fight, but his disagreements with other men were on questions of principle and policy, rather than on personal matters. Like all strong men, he had definite convictions and stood by them. Like all wise men, he listened to the opinions of others and based his conclusions on the evidence as he understood it. Like all socially mature men, he realized that human interests are often conflicting and that compromises are necessary. Like all other men, he doubtless at times made mistakes—let the man who has not done so cast the first stone.

Cattell was a scientist, and as a scientist his influence was greatest and will live longest. He carried out many researches, he inspired others to engage in scientific research, and as a scientific statesman he served science as a whole. Although these various activities grew out from the same roots, the blossoming and fruits were apparently so independent of one another that they may be considered separately.



JAMES McKEEN CATTELL, 1860–1944

Cattell's researches in psychology began within two years after he became a student of Wundt in Leipzig, in 1883. He published three important papers in 1885 which reflected the influence of his environment, for in them he approached psychology as an experimental science, not one in which the mind turns on itself and pursues itself and its reflections through the obscure labyrinths of consciousness. The following year (1886) he published four papers, all on experimental determinations of the physiological aspects of human mental activities. His series of five papers on "The Time Taken up by Cerebral Operations" filled seventy-two pages of the journal *Philosophische Studien;* they were printed in *Mind.* In 1887 he published but one research paper, for this was a year of travel and of his appointment to a position in the University of Pennsylvania. In 1888 he went to England and lectured at Cambridge University at which he opened a psychological laboratory. This was the year he had the good fortune to marry Josephine Owen of London. In this year also he published a research paper in the German *Philosophische Studien.* During this period he published fourteen principal papers.

After Cattell went to Columbia, in 1895, he worked more and more through his associates and students. He published several papers jointly with others, he introduced his students to his methods and inspired them with his ideals. He said a few years ago that more than 150 members of the American Psychological Association received their Ph.D. degrees at Columbia University. Among those who remained at Columbia as professors and gave this institution leadership in the fields of the mental sciences are Edward L. Thorndike, R. S. Woodworth, H. L. Hollingworth, A. T. Poffenberger, and Arthur I. Gates. With such men carrying forward researches along many lines, Cattell turned more and more to writing briefer reports and digests of his previous work and the work of others, reviews of books, addresses, and expository articles on psychology and science in general. Several of them were published in *Science* and *Popular Science Monthly,* later *The Scientific Monthly.* We find in his bibliography such titles as "The Progress of Psychology" (1893), "The Rise of Psychological Teaching" (1895), "On the Distribution of Exceptional Ability" (1895), "Science in America" (1896). "The Advance of Psychology" (1898), "The University President" (1901), "Concerning the American University" (1902), "The Conceptions of Psychology" (1904), "Examinations, Grades and Credits" (1905), "The American College" (1907), "The School and the Family" (1909), "Doctorates Conferred by American Universities" (1911), "Science and International Good Will" (1908), "A Program of Radical Democracy" (1912), "University Control" (1913), "Science, Education and Democracy" (1914). "Democracy in University Administration" (1914), "Scientific Journals and the Public" (1915), "Science and National Welfare" (1915), "The Organization of Scientific Men" (1922), "Conflicting Moral Imperatives" (1924), "Scientific Research in the United States" (1926), "Psychology in America" (1929), "Education Under the National Government" (1931), and "A Scientific Approach to Emotional Problems" (1934). In addition to these articles he published two books, *University Control* in 1913, and *Carnegie Pensions* in 1919.

A number of the titles of papers and addresses that have been quoted show that as the years passed Cattell became more and more interested in the effects of science upon society and in general methods of advancing it. Early in his scientific life he realized the importance of scientific journals. As early as 1895, he acquired the weekly journal *Science,* established in 1883 by Alexander Graham Bell, which had run continued deficits and was about to discontinue publication. In spite of initial financial losses, he improved its quality and in 1900 it was made the official journal of the American Association for the Advancement of Science. He and Mrs. Cattell edited and maintained high standards for this journal for nearly fifty years. In that time they prepared the manuscripts for publication, read the proofs, arranged the material for the printing of over 2500 issues of *Science,* containing about 60,000 pages of type. Only those who have done editorial work conscientiously can

realize the immense and lifelong drudgery that Dr. and Mrs. Cattell endured in editing *Science*. But this is only a part of the work of the kind that they did. In 1900 Dr. Cattell acquired *The Popular Science Monthly* (since 1908 *The Scientific Monthly*) which he controlled until the spring of 1943 when it was transferred to the American Association for the Advancement of Science. In 1906 he began publishing at about five-year intervals *American Men of Science,* the seventh edition of which will contain biographical sketches of about 34,000 scientists and is about to appear from the press. In 1908 he assumed control of *The American Naturalist,* and in 1915 he established the weekly educational journal *School and Society.*

Cattell was also prominent in scientific organizations, having been a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, the American Association for the Advancement of Science, of which he was president in 1924, and several professional societies. His influence was important in every society in which he took an interest. For about forty years he was the dominant figure in the American Association for the Advancement of Science, publishing its official journal, establishing its business procedures, guiding its policies, and nominating its principal administrative officers. Although many men contributed to the success of the Association during this period, Cattell was the only one who gave it continuous attention for more than forty years. In a very real sense he was a scientific statesman, seeing clearly the great new forces at work in the world, organizing and directing them wisely for the benefit of society, and supporting similar activities by other men.

There was another side to Cattell besides that of conducting and stimulating research, founding, editing and publishing journals and playing important roles in organized science. Early in his career he established his home on an isolated mountain top overlooking the Hudson River. There his children grew up. There he looked up at the glories of the stars at night and down at the glories of the trees by day, particularly in spring and autumn. Below he saw the sunshine and sometimes the fog on the river in the valley, and sometimes, in winter, he looked down on a pure white world and thousands of his Christmas trees sparkling with jewels. That he should have established and maintained such a retreat shows a side of his nature known to but few, for he did not display emotions so sacredly personal. Who can say that he really understood Cattell and who can explain the origin of his great abilities and his tireless use of them for the advancement of science?—F R. M.

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## A PARABLE FOR PEACEMAKERS

By ALEXANDER F. SKUTCH

HERE in this tropical valley live untold thousands of birds of several hundred distinct kinds. They dwell together in a degree of peace and harmony that is surprising when one considers their number and diversity of habits. Since a large proportion remain paired throughout the year and occupy continuously the little plot of ground in which they nest, disputes for the possession of mates and nesting-ground are far less frequent and violent than among northern birds, which in general are migratory and each spring must find mates and claim their nesting territory anew. Here predatory members of the avian world are rare; and an almost Utopian good-fellowship prevails among the local birds.

But there is one outstanding exception, one perpetual disturber of the harmony that prevails among two hundred kinds of birds. It is a small flycatcher, with dull brownish upper-plumage and a dingy yellow breast streaked with narrow dusky lines—altogether a bird neither beautiful nor distinguished in aspect, and one that would attract the eye of none but the enthusiastic bird-watcher armed with his field glasses. Early in the sunny month of February, this plainly clad little flycatcher arrives in our valley, and at once proclaims his presence by a variety of thin-toned, breezy whistles that seem to be the spontaneous outpouring of a careless, easy-going, vagabond nature. In these airy, carefree utterances, one searches in vain for some trace of the earnestness of his neighbor and relative, the yellow-breasted chipsacheery flycatcher, the depth of feeling of the brown thrush, or the retiring modesty of the blue grosbeak. They seem to be the self-revealing expression of a nature at once light-hearted and shallow, bound by no ties. Only the persistency of his repetition of the long-drawn *pee-e-e-e,* and the high-pitched, rapid *pee-de-de-de,* might lead the perspicacious student of avian nature to suspect that there lurked behind that voice a vein of stubborn pertinacity unexpected in a character so gay and breezy. Yet, if poetry flourished here amid the vast forests of southern Costa Rica, the local bards might seize upon and celebrate the voice of the striped flycatcher as the true harbinger of spring, as European poets have taken the voice of the cuckoo, and North Americans the songs of the bluebird and the robin.

Yet, to a certain section of the local bird population, I fear that the airy whistles of the striped flycatcher are anything but a message of gladness and good cheer. At this season, I fancy that I hear the yellow-breasted gray-capped flycatchers exclaiming to their mates in their thick, earnest voices, and the chipsacheeries repeating in their soft, high tones: "Confound it! So that pest is back again!"

For in March, the month of gathering clouds and the first light evening showers, the gray-caps and the chipsacheeries, together with a host of other birds of the most diverse kinds and colors, begin to fashion their nests, that they may bring forth their young in the verdant, flowery period of April and May, when flourishes an abundance of insect life that lightens the task of filling hungry nestling mouths. But not so the striped flycatchers; instead of setting about to prepare their nests, they continue to perch idly in the treetops, now and again darting forth to snatch up passing insects, and continue their thin whistles, as breezy and care-

free as ever. Not for this pair the joyous occupation of choosing, male and female together, the site of the future nest, amid the dark foliage of orange or lemon tree, or at the leafy end of some long bough overhanging the sparkling current of the river, close beside a hive of stinging wasps that will fiercely punish any heavier, less aerial creature that shakes the swinging branch. Not for the female striped flycatcher the pleasant task of building the nest, while her mate perches close by, dropping a cheery note of encouragement each time she passes him with a straw in her bill. The striped flycatchers have other ends in view; they watch and whistle while other birds build their nests.

At length, after a week or two of unhurried labor, the gray-cap, or her cousin the chipsacheery, has completed her nest, a commodious structure of dry straws and weed stems, with a high domed roof to shield the occupants from sun and rain, and a wide round doorway in the outer side. A few mornings later she lays the first of the white eggs wreathed with brownish spots, then two or three more on the following days. Now is the time for the striped flycatchers to put in their master stroke of strategy. It is not without a purpose that they have waited all these weeks in the tops of neighboring trees, appearing so blithe and innocent, yet watching every move of their intended victims, and quite aware of the precise stage of the nesting operations of the particular gray-cap or chipsacheery they have chosen as their dupe.

One fine morning, after the eggs have been laid in the domed nest, one of the striped pair ventures closer than the owners will permit. Then one of the yellow-breasted owners, as likely as not the male, darts at the intruder, who at once prudently retires. Perhaps the female yellow-breast joins in the aerial chase. The longer and hotter the pursuit, the better for the purposes of the striped flycatchers. While one of the pair decoys the owners away, the other enters the unguarded nest, takes a spotted egg in its bill, flies out and drops it to the ground. They have scored their first point in the unequal contest. Then they go off a while, insect catching and calling, and at their convenience return for the second round. The yellow-breasted owners of the nest, excited and angry now, dart fiercely at them, determined to drive away these impertinent thieves. The chase is hot, pursuer and pursued twist and double until it is difficult to follow their movements with the eye. But the defense of the yellow-breasts reveals more zeal than strategy; in their spirited sally to drive the trespassers away from their citadel, they have neglected to maintain a garrison. Again the striped birds' opportunity arrives and soon a second egg lies broken on the ground. When the last of the three or four eggs has shared the same fate, the contest ends, as it always does, in favor of the striped flycatchers. Although the battle was spectacular and noisy, with both sides voicing their characteristic cries, none of the contestants suffered personal injury greater than the loss of a few feathers.

Few birds will lay a second time in a nest that has been pillaged. So the gray-cap or chipsacheery who has lost her nest soon begins, hopeful and industrious as ever, to construct a second domed nest close by, leaving the plundered structure in possession of the invaders. These carry in a loose handful of small dry leaves—which the builders of these domed nests never themselves take in—as though they felt constrained to make at least a pretense of useful effort. Among this loose litter the female striped flycatcher lays her three grayish-brown, mottled eggs, and incubates them while her mate whistles in impudent exultation from the nearest treetop. And these thieving birds, once established in their ill-gotten home, guard it with as much zeal, and attend with as much care and affection the eggs and young it shelters, as though they had built it with their own bills. Frequently the female may be overheard singing to herself a sweet little song of love and contentment as she sits over her eggs.

The season is now well advanced, and the dispossessed yellow-breast labors with more concentrated energy to finish her second nest. Soon it is completed, a new set of eggs deposited in it, and the patient task of incubation begun once again. Occasionally, during an interval when the second nest of its victims remains unguarded, a striped flycatcher will remove an egg from that nest; more from

habit than from malice. But in general, all goes well with the replacement nest of the yellow-breasts—provided snake and weasel and hawk and destructive boys fail to pass its way—so long as the striped flycatchers prosper in their stolen nest near by. But the eggs and young of the home-robbers are preyed upon by the same enemies that take toll of the offspring of the home-builders. If they are lost, as may happen in from a quarter to a half of all the nests occupied by the striped flycatchers, they will not again entrust their eggs to the structure that has been once pillaged. Instead, they demand another commodious domed nest of their dupes, the yellow-breasts, and will most likely throw out the new set of eggs that the female yellow-breast is incubating in her second structure near by, causing the unfortunate bird to build yet a third. One might suppose that the unhappy pair would withdraw to some more distant locality to construct their later nests, instead of placing them within such easy reach of their persecutors and despoilers. But as a rule, this is not feasible; were they to go in search of another area suitable for their breeding operations, in all likelihood they would find it already in possession of another pair of their kind, who would resent their intrusion, and who most probably had also to contend with a pair of the pestiferous stripe-breasts. So the long-suffering gray-caps and chipsacheeries linger upon their own home ground chosen many months before, and hopefully build nest after nest there, until at length, unless they have more than usual bad luck, one is successful, and their bright-eyed fledglings, safely past the most critical period of their lives, fly from its shelter, and clamor incessantly for food in the neighboring trees.

Thus, when a pair of the yellow-breasted flycatchers is selected by a pair of striped flycatchers as their victims, they not only lose their first nest but may lose their subsequent nests. Consequently, *their success depends to a large extent upon the success of their persecutors*. The safety of the second nest occupied by their eggs and nestlings is not bound up in this nest alone, but also in the earlier structure stolen from them by the striped flycatchers, and the risk of loss is doubled. Fortunately, the chipsacheery and gray-capped flycatchers are hardy, prolific species, widespread in tropical America. The striped flycatcher, like the chipsacheery (the wider-ranging of its victims), spreads over a vast territory stretching from Mexico to the northern districts of the Argentine Republic, but in most parts of its range is far less abundant than the two yellow-breasted species whose nests it occupies. And these, despite the loss of so many nests to the striped thief, are in extensive regions of the American tropics among the most abundant and familiar of birds about the dooryards of men, in pastures with scattered trees, and along the shores of rivers and lakes. They avoid the heavy, unbroken forests where conditions are not favorable for their flycatching.

## II

Here Nature herself has created a situation that points as profound a moral as any parable sprung from the fecund imagination of Aesop, La Fontaine, or Iriarte. Of the main events in the struggle between the striped flycatcher and its victims I am perfectly sure, having witnessed it not fifty yards from my dwelling. And each year, over a vast territory in the warmer countries of America, this little drama of bird life is acted many thousands of times over; as it has been, no doubt, during untold centuries stretching beyond the dawn of human history. Here is a relationship between two antagonistic species so old, so firmly established, and so widespread, that it may well be worthy of our serious examination. The reader, if he is acquainted with none of the chief protagonists—if he has never heard the long-continued dawn-song from which the chipsacheery flycatcher takes its name, and has seen nothing of the devoted industry of the gray-cap as she fashions her domed nest—will have formed no prejudices in favor of one side or the other, and can the more dispassionately and unerringly draw conclusions from their strange history.

For I, after long acquaintance with these attractive birds, have become the partisan of the aggrieved party. Once, while witnessing the conflict between a pair of gray-caps and a pair of striped flycatchers for the possession of the former's nest, I longed to be able

to drop a word of advice into the ear of the defenders. "Instead of dashing foolishly in pursuit of your slippery assailants," I wanted to tell them, "keep your citadel constantly garrisoned. Take turns at warming your eggs, keep them constantly covered and the pesky little stripe-breasts will never be able to harm them."

But I fear that this would have been advice proffered in vain. In all the great family of the American flycatchers, I have not, in years of study, discovered a single species of which the male takes a turn on the eggs. For a male flycatcher to sit in the nest would be as preposterous and unconventional as for a male woodpecker or a male antbird to fail to take his full share in warming the eggs and brooding the young. Being conservative by nature, doubtless the gray-caps would rather continue to risk the loss of their nests, than to change the age-old customs of their kind; just as those who have been born and raised upon the slopes of a volcano will linger there, under the constant menace of a disastrous eruption, rather than seek a safer home in strange parts.

What, then, could the gray-capped flycatchers and the chipsacheeries do to put an end to this annually recurrent and oft-repeated outrage? Here is a problem that has sometimes amused me upon my solitary walks. They might unite against their tormentors and attempt to make an end of them in an active war of extermination. But in this it is not likely that they would be successful; for the striped flycatchers, although smaller and weaker, are sufficiently swift and agile to elude their pursuers. Or they might become disciples of the Mahatma Gandhi, wage a passive rather than an active warfare, and refuse to build nests at all, seeing that so large a proportion of them are made for the use of others. But this Gandhian policy, also, could not be wholly successful; for the two species of yellow-breasted flycatchers, although the chief victims of the striped-breasts, are by no means the only ones. The nest-thieves occupy a considerable variety of covered or closed nests, including the long, woven pouches of the oropéndolas and other members of the oriole family, the snug globular structures of fibrous and downy materials built in the tree-tops by becards, and have even been known to take possession of the nest-chamber carved by gartered trogons into the heart of a big, papery wasps' nest. It is probably in such situations that their litter of dead leaves is of service, for trogons do not line their nests with soft materials. But there is no record of the striped flycatchers' ever having made use of an open nest, such as those of thrushes, tanagers, sparrows, and the great majority of songbirds. Hence, were the yellow-breasted flycatchers to go on strike and refuse to build, the striped flycatchers would be deprived of the most important, but by no means the only, source of their nests. By such a course, the yellow-breasts would be more likely to accomplish race-suicide than the extermination of their enemies.

Or, taking the philanthropic—or should it be philornithic?—view, the chipsacheeries and gray-caps might establish schools to teach the less gifted striped flycatchers how to build their nests. But in such a high-minded endeavor, the auguries of success are not encouraging. Students of evolution have crystallized certain of their conclusions in the so-called "Law of Loss." They have discovered that when once an organism, in the course of many generations of evolutionary change, loses an organ, that organ is never recovered. If, as a result of secular changes in environment, external conditions recreate the need for the lost part, it is not reconstituted in its primitive form, but at best a substitute is gradually developed. Thus plants of a number of kinds, at home in arid regions, have little by little quite lost their leaves. When one of these plants again finds itself growing under humid conditions where the possession of broadly expanded leaves would be an advantage, it cannot recover its lost foliage in the original form, but at best, during the course of many generations, develops substitutes of quite distinct origin, such as flatly expanded stems or leaf-stalks. What applies to organs probably holds equally true of instincts, such as that of nest-building. As well attempt to help a snake sprout forth again the legs enjoyed by its remote ancestors, as to teach a striped flycatcher to fashion a nest such as its forefathers once built.

All things considered, it is probable that

the best course the victims of the striped flycatchers could take is that which they already follow. Indeed, it is not likely that the philosophic naturalist, in his comfortable armchair or on his musing evening walks, can improve upon the ways Nature has developed as the result of countless millions of trials covering many thousands of years. Yet I make bold to suggest an improvement, in one small point, on the course actually followed by the yellow-breasted flycatchers: that instead of making a nest in the vain hope of using it themselves and laying eggs only to have them thrown away, each pair of yellow-breasts, at the outset of the breeding season, build a nest especially for the pair of striped flycatchers that has attached itself to them, and when it is completed, lay no eggs there, but respectfully invite their persecutors to move in and have joy of it. Then, chirping praises of their own philornithy in providing their poor relations with the means to perpetuate their kind, they can go ahead and build another for themselves, with better prospects of remaining in possession. But let them fashion the nest intended for the striped flycatchers with all the care they bestow upon that destined for their own offspring; for if the first is flimsily built and collapses in a rainstorm, the tenants will, as I once saw, abandon it, and dispossess the yellow-breasts of their more sturdily built second nest. And let the gray-caps and chipsacheeries wish success to those for whom they have built; although they may not love those clamorous, improvident creatures, they have every reason to wish them good fortune, knowing full well that any mishap that befalls the striped-breasts' nests will be also their own misfortune. For the prosperity of the highly gifted yellow-breasted flycatchers is linked with the welfare of the deficient striped-breasts.

## III

Our study of a certain peculiar situation existing among the birds of tropical America has led to the quite unexpected conclusion that the best course certain persecuted species can follow is, if not to love, at least to wish well to a second species as a result of whose deficiencies they are grievously annoyed. Nature herself, Nature "red in tooth and claw," has taught, in this instance at least, a rule of conduct closely approximating some of the doctrines of Christ often looked upon as fantastically idealistic and quite inapplicable to conditions as they actually exist in this world of conflict and brute force. To love their enemies, to turn the other cheek in the figurative sense, is the course of action which will bring the yellow-breasted flycatchers the maximum of success in their endeavor to reproduce their kind, with the least amount of annoyance. And this is, in effect, the course they actually follow, with cries of wrath and unchristian complaints, no doubt, yet with no great resistance. I have never known a yellow-breasted flycatcher to try to settle accounts with the despoiler of its nest by vengefully throwing out the intruder's eggs—an act which, as we have seen, would only redound to its own further loss.

One lesson more may be drawn from this strange situation. We commonly assume that the strongest, the most perfectly equipped species, will be most successful in the struggle for existence. But this is by no means universally true. Some organisms are eminently successful by virtue of their very weaknesses. The striped flycatchers, with their grave deficiencies of instinct, lord it over the obviously better equipped yellow-breasted flycatchers, which to our eyes are a "nobler" species. Seeds of a vine and a great tree germinate side by side in the dim light of the forest floor. The light-starved tree seedling grows with extreme slowness; it must form a self-supporting trunk as it increases in stature, and can never mature and fructify unless one of the giant trees above fall and make an opening in the high canopy where it can spread its ample limbs and enjoy the full sunlight. But there will be many competitors for this gap when at length it occurs; and the seedling's chances of ultimate success are exceedingly slender. But the vine, which will never be able to hold itself erect, twines slowly upward from limb to limb and from tree to tree, until at last it spreads a tangled maze over the loftiest of them all, and displays its brilliant blossoms over the roof of the forest. Its very lack of a self-supporting stem contributes to its suc-

cess; the necessity to form one, to complete itself, causes the failure of the seedling tree.

IV

The problem of the striped flycatcher is not confined to the bird world alone; it is of far broader significance. Striped flycatchers we have always with us. In human society they are the underprivileged, the disinherited, the inept. But the advantage of considering the problem as it occurs among birds is that we can do so dispassionately, and so reach truer conclusions. Human problems are so bound up with our fears, hopes, and prejudices that only with difficulty can we give them the detached, objective consideration essential for reaching solid conclusions about our social behavior.

In the tropical valley where I dwell, the welfare of two highly endowed species of birds is intimately dependent upon that of a third species with a conspicuous deficiency which—without justification, as we see it—makes a claim upon their superior endowments. The security of their homes and families hangs upon the safety of the homes wrested from them by their poor relations. The happiness of some of the noblest birds in the valley is linked with that of one which, from the point of view of the human moralist, is the most ignoble of them all.

Is it otherwise in human communities? I think not. In a hundred ways, some direct, some subtle and tortuous, the welfare and happiness of the ablest and most gifted members of a society are dependent upon that of the poorest, the meanest, the most defective —the striped flycatchers among us. The diseases that breed in the slums and the shacks of the indigent find their victims at length in the comfortable homes of the prosperous. The vices which lurk there creep into the well-ordered families of the substantial citizens. The thieves created by idleness and destitution take toll of the goods of the well-accommodated. If the underprivileged class is sufficiently numerous, then the political and economic systems of the country are disordered, the entire moral atmosphere polluted. Longer-suffering than their feathered prototypes, restrained by law, custom, and the whole ponderous superstructure of the social system, the human striped flycatchers do not assert their fundamental needs with such salutary regularity. But if their deficiencies become too acute, their sufferings too dire, they rise up with energy and wrath that shake the whole social order to its foundations and strike down the lords of the land.

But in ways still more subtle and immaterial, our happiness is influenced by even the least of the creatures around us. Sensitive persons are peculiarly affected by the proximity of suffering and distress. The sight of a crippled beggar, a mistreated child, a fly-tortured horse, a broken-winged bird, or even a mutilated butterfly, casts its shadow of melancholy, large or small, over the sunlit fields of the fairest morning. Those who know how to live well try to surround themselves with creatures in good health and fine spirits. The raw-boned horse and the woebegone dog are not found in the possession of sensitive people.

The psychology of happiness has never been fully analyzed. How is it that great catastrophes, such as wars, plagues, and earthquakes, throw a cloud of unhappiness, proportioned to their magnitude, over persons far removed from actual contact with them, hardly affected even by their indirect consequences? By what mystic bonds of sympathy, what obscure telepathy of suffering, does this action at a distance occur? Perhaps, in some fashion we fail to understand, all suffering, whether of man or other living creatures, no matter how remote, exerts its proportioned influence upon our spirits and prevents our happiness from attaining its fullest measure. Perhaps none will ever enjoy full, unruffled beatitude until—O, when?—misery and pain quite vanish from the earth.

In smaller spheres of action, the dependence of our well-being upon that of the creatures around us is becoming increasingly evident to thoughtful men. The farmer who applies the doctrine of "cure or kill" to his suffering domestic animals has taken the first step in the practical application of this philosophy. Only savage, insensitive natures can endure to be surrounded by maimed, suffering, or mistreated animals. The same applies with added force to our own kind. The degree of civilization of a community or a nation may be gauged by its effort to educate the underprivileged, that they may create for themselves the things they need

for the completion of their lives, for their happiness. In all enlightened countries, the congenitally defective and inept—those true striped flycatchers that can never be taught to build their own nests—are supported by public charity or kept in appropriate institutions. These benefactions in favor of the underprivileged are a huge drain upon the resources of the community; but wise administrators and thoughtful citizens do not doubt the wisdom of making the sacrifice, just as the yellow-breasted flycatchers have learned, under Nature's wise tutelage, to give up their nests to the striped-breasts without too much resistance and with no revengeful reprisals. Peace and harmony are bought only at the expense of giving the unendowed their vital needs or by exterminating them. A few modern states, unshackled by tradition or by compassion, have attempted the eradication of their striped-breast class. The wisdom and the practicability of this policy remain to be proved.

## V

Logically, it requires but a short step to apply to the family of nations the parable that points so plain a lesson in situations where selfishness and prejudice do not blind us to its truth. Yet in practice it is a step so long that only a few of the most far-sighted of statesmen have been able to take it. From the example of Nature, as from civic experience, we have learned that where a striped-breast class exists, peace and security can be attained by either of two methods: by its extirpation or by yielding to its necessities with the best grace we are capable of assuming. The rule still holds when we turn from birds and men as individuals to those aggregations of men called nations.

An underprivileged nation is one poor in natural resources, or with insufficient territory for its population, or with position and empire inferior to that which the ability of its people entitle it to hold. Add to these that most dangerous class of all: nations intellectually or temperamentally unfitted for self-government. All such countries must sooner or later come into armed conflict with their better endowed neighbors. Perhaps, now that the days of dynastic wars are gone, and the world has ceased to be a chessboard over which rival princes play for fiefs and vassals, it would not be far from truth to state that only such countries fight with their neighbors. For like the striped flycatcher, like the underprivileged classes in the social structure, no nation will long rest quiet without the things it needs for continued existence. It will not succumb without a death-struggle.

When a population of birds, or a community of men, has learned that the welfare and stability of the group can best be maintained by submitting to sacrifices in behalf of the underprivileged and handicapped individuals, it appears to follow that the general health of the family of nations can best be secured by a like policy. Those countries on the west coast of South America whose territory extends across the Andes possess large areas with no natural outlet save by way of the Amazon River, flowing for two thousand miles through territory undisputedly Brazilian. Years ago, Brazil declared the great river open to international navigation, when she might have kept it closed with lucrative tariffs, and as a result the largest country in South America lives in unruffled amity with her neighbors to the west. The great nation of Poland was, in a sense, in much the same situation as the vast but thinly populated Oriente of Peru; it could obtain access to the sea and free international commerce only through foreign territory. The "Polish Corridor," so important to the nation it served, without doubt caused inconvenience to the Germans whose territorial continuity it severed. Less liberal than Brazil, Germany would not abide this inevitable annoyance; and Poland's outlet to the oceans became one of the causes leading to universal conflict.

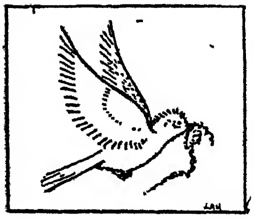
Peace will reign only when nations learn to make sacrifices to preserve it, to abide with good-humored patience inconveniences which arise from unavoidable international difficulties, and to feel an obligation toward neighboring countries less fortunate than themselves—in short, when they learn to act generously instead of selfishly. Alas! it seems that nations must ever be less noble than many of the men who compose them. Individuals have not infrequently been known to perform acts of spontaneous generosity; nations, almost never. Individuals have times without number made sacrifices—

even the highest sacrifice—for the public good. When has a nation spontaneously made a genuine sacrifice for the good of mankind? National honor is far inferior to the best individual honor, so-called "national honor" being a species of arrogant, swaggering pride, rather than a scrupulous care in the performance of obligations. No prudent man would care to do business with an individual or firm that could produce no better record of the fulfillment of contracts than the majority of nations have shown throughout history.

It is as imprudent for a country of great wealth, culture, and resources to allow itself to be surrounded by rude, impoverished neighbors, as for a rich man to live among starving paupers. The rich man, if wise and farsighted, will increase his security, and probably also his wealth, by helping his neighbors to earn an adequate living. But there may come times when he is called upon to give them bread to protect himself.

But with certain nations, diseased by greed or intoxicated with delusions of their own grandeur, no degree of generosity, no amount of graceful yielding, can bring peace and conciliation. Such countries no longer struggle for the means of existence; they are content only with domination. What nation could have yielded to the demands of the Persia of Darius, the Macedonia of Alexander, or the France of Napoleon, and continued to exist? Carthage and Rome, as two states whose pride and ambition had no bounds, were well equipped to understand each other. Their statesmen knew that conciliation was impossible and no peace between them could be lasting, because neither could brook any limit to its power. It is as though the striped flycatchers, not content with the single nest they must have or fail to reproduce their kind, believed that their noble qualities entitled them to every nest the yellow-breasted flycatchers could build; then for the yellow-breasts there would be no middle course between destroying the striped flycatchers and being destroyed by them.

## ALEXANDER F. SKUTCH—NATURALIST



DR. SKUTCH was born in Baltimore, Maryland, in 1904. His formal education was obtained in Baltimore, first in private schools and then at Johns Hopkins where he received his doctorate in botany in 1928. His own story follows: During my undergraduate years, I spent the summers on Mt. Desert Island, Maine, studying the northern plant-life, especially that of the seashore. During the summer of 1926, I enjoyed my first glimpse of the tropics, on a botanical expedition to the island of Jamaica. Here we stayed for six weeks in the Blue Mountains. After the return of the party, I settled down for six weeks more on a banana plantation to make a study of the anatomy of the banana leaf for the United Fruit Company—this became my doctor's dissertation.

In 1928 I went to Almirante in western Panama on a fellowship from Hopkins to continue my studies of the banana at the research station the United Fruit Company then maintained there. In 1930 I continued these studies at Tela, Honduras. Upon these visits to Central America, I became deeply interested in the bird-life. I found that the birds of this region had all been classified, but exceedingly little was known about how they lived. I resolved to dedicate myself to this study. In 1932 I spent half a year on a banana plantation on the border between Guatemala and Honduras, making an independent study of the birds. I spent all the following year studying the birds of the Guatemalan highlands at elevations ranging from 7,000 to 10,000 feet and here I also made a collection of the plants. This led to a commission from the Arnold Arboretum of Harvard University to collect for them during the following year in the Guatemalan highlands.

In 1935 I came to Costa Rica, with plans to combine my studies of the birds with botanical collecting as a means of support. Hearing much about the Valley of El General, I resolved to go there. I found a pioneer community, with unspoiled forests on the very outskirts of the principal village. The local *Jefe Politico* was most helpful; through him I acquired a cabin with a thatched roof in Rivas, where I dwelt for a year and a half—thrice the length of my intended visit. Later I spent two more seasons in natural history work in other parts of the valley.

At the beginning of 1940, I accepted the post of curator of the herbarium in the Museo Nacional in San José, but resigned after six months to go to Peru, Ecuador, and Colombia on a rubber survey party for the U. S. Department of Agriculture.

Having come to look upon the Valley of El General as home, I returned in 1941 and bought a farm of fifty hectares (about 125 acres), so newly carved from the forest that the pastures are even now littered with logs and stumps. Here I have been living since then, doing subsistence farming—keeping sufficient horses and cattle for the work of the farm. All the time the farm work allows—a good deal in the wet season—I devote to studying the wild-life and to writing.

# METEOROLOGICAL MILEPOSTS

By HARVEY A. ZINSZER

METEOROLOGY (meteora + logos), the science of things supraterrestrial, began with the observations of primitive peoples whose outdoor occupations of hunting, tending flocks, and cultivating the soil depended greatly upon the weather. Some of the earliest writings extant contain fragmentary references to weather phenomena. For example, *Job*, supposedly written in 1520 B.C., and *Ecclesiastes*, written about 977 B.C., both contain speculations regarding the weather, some of which are believed to have been old even at the time of their recording. The weather rule which taught that the first twelve days of the year indicated the type of weather for each of the ensuing months was traced back by Hellmann to the fifteenth century B.C. The ancient Chaldeans and Babylonians, pioneers in the science of astronomy, tried to connect the phenomena of weather with the motions of the heavenly bodies. The Greeks, too, were forerunners in the field of meteorology, for in Athens today there stands the Temple of the Winds, an edifice erected about 100 B.C. for observing the direction of the winds. It is an octagonal tower constructed of marble, and at the top of each face is a sculptured figure of one of the winds.

However, the earliest known effort at a systematic discussion of meteorology was the *Meteorologica* of Aristotle (384–322 B.C.), which was the standard work for two thousand years. About 400 B.C. Hippocrates, the Father of Medicine, wrote the first treatise on medical climatology with many interesting inferences; while Theophrastus, a pupil of Aristotle, wrote treatises on winds and weather signs. It is also known that in India rain measurements were made as early as the fourth century B.C. and that wind vanes were used in the first century B.C.

Perhaps the first meteorological instrument with a reacting substance was the hygroscope of Cardinal de Cusa (1401–1464) for determining humidity by weighing balls of wool under various moisture conditions. In about 1500, Leonardo da Vinci constructed an improved wind vane and a mechanical moisture indicator. The period of exact weather observations had its beginning in about 1590 with the invention of the thermometer by Galileo and Sanctorius of Padua. In 1643, Torricelli, a pupil of Galileo, invented the barometer known as "Torricelli's tube." Five years later, Pascal persuaded his brother-in-law, Perrier, who lived near Puy-de-Dome, a mountain in southern France, to ascend the mountain to determine whether the height of the mercury column in the barometer would diminish with altitude. Perrier's observations disproved the old belief that "nature abhors a vacuum," and showed conclusively that atmospheric pressure diminishes with altitude.

The transition from visual to instrumental observations, or rather the movement toward exactitude in the field of meteorology, was attended by a long series of discoveries and inventions. Pendulum anemometers for measuring the force of the wind were erected in Bologna and in Florence by the astronomer Egnatio Danti, about 1570. The Italians also developed the rain gauge, which was first used by Beneditto Castelli. Other discoveries contributing to the science of meteorology were: the condensation hygrometer for measuring moisture in the atmosphere, by Ferdinand II of Tuscany in 1650; the law of "the Spring of the Air," discovered in 1660 by Robert Boyle and later named after him; the meteorograph, by Wren in 1664; the introduction of the freezing point and boiling point of water as reference points on the thermometric scale, by Huyghens in 1665; the Fahrenheit scale in 1710; the hair hygrometer, by de Saussure in 1783 (de Saussure also showed that damp air is lighter than dry air at the same temperature and pressure); the wind force scale, by Admiral Beaufort in 1805; the psychrometer by August in 1825; the pyrheliometer for measuring the sun's heat, by Pouillet in 1837; the aneroid barometer, by Vidie in 1847; culminating with the perfecting of the radiosonde (radiometeorograph) for radioing from aloft values of atmospheric tempera-

ture, pressure, and relative humidity, by Diamond and Hinman of the Bureau of Standards in 1936.

Since winds were obviously of paramount importance in the era of sailing vessels, we find von Verulam announcing, in 1624, the rotation of the winds with the sun; while in 1686, Halley gave the first account of the trade winds and the monsoons. Thus was attention soon directed to such traveling disturbances as cyclones and tropical storms. Already in 1687, Dampier recognized typhoons as revolving storms; this was also found to be true of cyclones by Brandes in 1820, and of hurricanes by Redfield in 1840. Perhaps the most significant discovery of this kind was that of Franklin in 1747 when he found from but two observation points that the local weather may be a small part of a meteorological configuration passing over the country. Franklin had planned to observe an eclipse of the moon in Philadelphia; he wrote his brother in Boston requesting him to make similar observations from there. On the day of the eclipse it was stormy in Philadelphia with rain from the northeast. Franklin learned later, and to his surprise, that it was clear in Boston at the time of the eclipse but that soon thereafter a northeast rain occurred. Hence he discovered that though the rain as it fell appeared to come from the northeast, the storm actually traveled northeast from Philadelphia to Boston.

The study of heat and thermodynamics which underwent a considerable development in the first half of the nineteenth century contributed much to the science of meteorology. Watt had invented the steam engine in 1765, and Lavoisier had established the true nature of the atmosphere in 1783. The law of partial pressures pertaining to a mixture of gases was given by Dalton in 1800, thus making it possible to determine the individual pressure of water vapor in the atmosphere. Dalton also wrote an epoch-making paper on the effects of rarefaction and condensation, which laid the foundation of modern physical meteorology. Carnot's book, *Réflexions sur la puissance motrice du feu,* written in 1826, introduced the so-called Motor Age leading to modern transportation and present-day aviation with its profound influence on meteorology. In 1830, James P. Espy announced the important principle of the cooling of air as it rose and expanded, and in 1841 he published his *Philosophy of Storms* in which he stated the importance of the expansion of rising air in the formation of thunderstorms and clouds. Almost simultaneously, Dove published his theory of storms with indications that storms originate when polar air and tropical air are brought into juxtaposition. This was followed in 1856 by Ferrel's theory of general circulation in which, by the application of dynamic theory, he showed the effects of the earth's rotation on a mass of moving air.

While the observations of Tycho Brahe from 1582 to 1598 comprise the earliest systematic meteorological records, we find the Chevalier de Lamarck (1774–1829) working with Laplace, Lavoisier, and others in establishing a network of observing stations, and publishing a series of *Annuaires Météorologiques* from 1800 to 1815. The earliest record of synoptic weather charts is, however, accredited to Brandes who, in 1820, produced a series of daily weather charts, one for each day of the year 1783, and who later published charts of the great storms of 1820, 1821, and 1823. He explained these storms as due to barometric depressions advancing from west to east over the earth's surface.

In America, Espy carried out similar researches; he established a service of daily synchronous observations and studied in detail the behavior of depressions. The work of Lamarck, Brandes, Espy, and others led to the establishment of networks of meteorological stations in several countries within the years of 1850–1856, the Meteorological Office in London having been set up in 1854. International cooperation was first established by an international conference held in Brussels in 1853, and was put on a sound basis by an international congress in Vienna in 1873. Meanwhile, in 1860, Buys-Ballot announced the so-called baric wind law which states the relation between wind and pressure distribution; namely, if the wind is to your back, the pressure is lower on your left than on your right in the Northern Hemisphere; and oppositely for the Southern Hemisphere. The first map of pressure distribution over the entire world was produced

by Buchan in 1869; it was followed by Mohn's storm atlas in 1870.

An interesting sidelight influencing the advent of weather maps occurred during the Crimean War (1854–1856), when a storm in the Black Sea caused considerable damage to the French fleet, especially to the battleship Henri IV. About this time, the astronomer Leverrier had won world renown by forecasting the existence of a new planet. Napoleon III apparently thought that if science could predict the whereabouts of hitherto unknown planets it could also forecast storms and weather. He therefore charged Leverrier with the difficult task of organizing a system of weather forecasting. Since there were no weather bureaus or organized system of reporting, Leverrier had to call upon observatories, universities, and a few observing stations that kept meteorological logs for data. From this material he plotted primitive weather maps by means of which a "post mortem" study of the Black Sea storm could be made. He found that the storm could be traced from one weather map to another and that it moved along a regular path and with fairly constant speed. The conclusion drawn was that if observations were made at a large number of stations and if reports could be transmitted with sufficient speed to a central office, one could by plotting and by analysis extrapolate a storm's future movement.

Naturally these results created a wave of enthusiasm, and the second half of the century saw weather bureaus established in several of the civilized countries of the globe. However, it was soon found that the problem of forecasting was more intricate than anticipated. Since at this time little was known of the normal state of the atmosphere, it was difficult to understand the perturbations superimposed upon it. The methods of forecasting were based mostly on statistics and rules of thumb, which were generally of local or regional value only. So the optimism created by Leverrier's report was soon followed by a period of dormancy which prevailed more or less until World War I when the problem of weather forecasting was attacked with renewed vigor and determination. In fact, the development of aviation since World War I has provided a greater stimulus for a rebirth of meteorology than the entire previous history of man.

In the United States, Professor Cleveland Abbe, Director of the Observatory in Cincinnati, with the assistance of the Western Union Telegraph Company, undertook, in 1869, to gather data and forecast storms. The results were so uniformly successful that the organization of the Weather Service as part of the Signal Service under the War Department occurred the following year. In 1891 the Weather Service was made a separate bureau and placed under the Department of Agriculture; and, under the able leadership of men like Harrington, Moore, Marvin, and Gregg, has been efficiently gathering data from hundreds of stations over the United States, analyzing it, and broadcasting the results in but a few hours. By authority of the Air Commerce Act of 1926 and the Civil Aeronautics Act of 1938, the Weather Bureau is today charged with the responsibility of furnishing an adequate meteorological service for aviation in order "to promote the safety and efficiency of air navigation in the United States and above the high seas."

In constantly endeavoring to maintain as complete a service as possible, the Weather Bureau has established about 550 stations at fairly regular distances apart along the civil airways in the United States, Alaska, and Hawaii; and, in addition, over 250 stations rather uniformly distributed off the airways for reporting weather. Reports are collected by teletype and radio from airway stations, and by telegraph and telephone from off-airway stations. These reports are then relayed to required points along the airways by the Department of Commerce radio and teletype systems. About 140 of the foregoing meteorological stations are equipped for taking upper-air wind observations by means of pilot balloons; while approximately thirty stations are equipped for taking radiosonde observations in which instruments carried aloft by balloons report conditions of temperature, pressure, and humidity by means of radio. At about 150 important airway terminals, qualified meteorologists of the Weather Bureau are on duty twenty-four hours a day, charting and analyzing

weather reports and discussing the meteorological conditions with pilots of the airlines.

In the past, almost all the observations used in the forecasting of weather were taken at or near the earth's surface, little use being made of observations taken at high altitudes. In recent years, however, upper air conditions and movements have been studied, and as a result changes have been made in the theory of formation and structure of cyclonic storms. The polar front theory of the formation of cyclones and the method of air mass analysis used in forecasting weather conditions were developed largely by the Norwegian school of meteorologists.

Since upper air analysis, so important in weather forecasting, is contingent upon meteorological information concerning the upper air, a brief sketch of the development of this phase of the science seems apropos. The first scientific balloon ascent was made in Paris by Charles in about 1803. Other ascents were made by Glaisher from 1862 to 1866. From 1890 on, sundry mountain observatories were erected to record the various meteorological conditions of the free atmosphere; in the United States, the pioneer mountain observatories were set up on Mount Washington and on Pikes Peak. Balloons and kites carrying instruments were also used with increasing frequency to obtain observations from the upper atmosphere. In 1901, Suring and Berson reached an altitude of 35,400 feet in a free balloon. A year later, Teisserenc de Bort and Assmann discovered the stratosphere; and, shortly thereafter, Gold and Humphreys gave a theoretical explanation for the formation of the tropopause. However, simultaneous observations from the free atmosphere in large numbers and over large areas were obtainable only after the airplane and the radio came into general use. The findings of Stevens and Anderson, who in 1935 ascended to a height of 72,395 feet above sea-level in the Explorer II, added considerably to the fund of knowledge in meteorology.

The vast uninhabited regions in the arctic and the antarctic were tempting fields for exploration, and much information was brought home by numerous polar expeditions to enhance our steadily growing knowledge of polar meteorology, a typical example being the work of Admiral Byrd at Little America. Another feature of considerable interest in meteorology are the early ideas of wave motion in the atmosphere promulgated by Helmholtz and modified later by Solberg in 1928. Perhaps the most outstanding achievements of the past quarter century in this field are the discovery of the polar front, the wave theory of cyclones, the air-mass and frontal methods of weather forecasting initiated by V. Bjerknes and his collaborators in Norway; and the method of isentropic analysis as initiated by Rossby and his collaborators in the United States.

A sense of accomplishment and genuine satisfaction attend the learning of the vagaries and reasons for the weather, for one of the most fascinating phases of knowledge lies in the ability to answer the question "why" with regard to natural phenomena.

Although the application of the use of expert meteorological prognostication in the present war should probably not be discussed in special detail for the duration, after the war an important chapter on this phase will undoubtedly be written revealing the remarkable happenings in this field.

# SCIENCE WITHOUT EXPERIMENT: A STUDY OF DESCARTES

By RUFUS SUTER

A FEW years ago Greta Garbo in the role of Queen Christine spoke of the Frenchman, René Descartes (1596–1650). This was one of the few times the name of a professional thinker has been mentioned on the screen; but if Descartes could have heard he might have been sad, for his few months as tutor to that royal lover of the strenuous life ended in his death. The scholar, who for years had been used to his bed until afternoon, could not withstand the rigors of a horseback ride at sunrise, which was the Queen's idea of the proper setting for a philosophic lecture.

There is propriety in remembering Descartes in the aura of a Garbo play. Some quaint shots could be made of the philosopher as a young soldier on the Danube in the service of the Duke of Bavaria, Maximiliàn. This was the beginning of the Thirty Years War, so notorious for its cruelties and religious fanaticism, though for Descartes little of the morbid side of the military life was evident. His time was spent in mathematical discussion with army engineers. One wonders how a soldier could have avoided so successfully the harsher experiences of war. But Descartes had the ability to take his ease in spite of environment, at any rate until he visited Queen Christine.

A picturesque shot could be made of the soldier snowbound for a day while returning to the army from Frankfurt where he had watched the coronation of the Holy Roman Emperor, Ferdinand. Alone and seated by a stove he made his discovery of the basis of true science, as the climax of a period of dreams and religious exaltation. He suggests Buddha sitting under the Bo tree rather than his Italian contemporary, Galileo, who laid bare the basis of science while measuring the speed of balls rolling down an inclined plane.

The most romantic feature about Descartes, however, is that in the hut near Frankfurt he discovered a scientific method which is not the one we know at present.

It requires effort for us today to understand a technique in physics, chemistry, or the like, other than that of experiment and observation. The effort is hardly less than that needed to conceive of a non-Pythagorean arithmetic or a non-Euclidean geometry. We will find it worthwhile, nevertheless, to recapture the technique of Descartes, because an understanding of why it failed will help in the appreciation of why the more prosaic technique of the master mechanic, Galileo, succeeded.

Before looking at his method we must pay attention to the historical circumstances in which it was born. We must guard against reading our acceptance of the experimental method into the minds of the first two or three generations of scientists; against picturing them as single-mindedly loyal to the principle of experiment in their revolt against the ancient teachings of Aristotle in the schools, churches, and learned communities of Europe. Although the fathers of modern science were at one in their struggle to dislodge the arid expositors of Aristotle, the fact is that like many another revolutionary party their unanimity stopped with their agreement about their common enemy. Otherwise they fought among themselves. After the foe had been overcome, several generations were needed to liquidate the right wing, of which Descartes was the leader. Only then did the left wing, the familiar succession of Galileo, Boyle, Newton, and Watt, have the chance to accomplish its mission.

To be more specific: struggling to dislodge the expositors of Aristotle were, on the one hand, men later known in the history of ideas as the empiricists, from the Greek ἐμπειρία, meaning "experience," and ultimately from πεῖρα, a "trial," suggesting that knowledge is the fruit of trial and error in the handling of the familiar things of everyday life. This technique, among speculators about the sources and limits of knowledge, eventually became refined so that the scientists themselves who used it would not

have recognized it. In its cruder form, however, in which it has been wielded for ages by artisans and engineers, and by the most inventive of the early modern experimenters, Galileo, it was practical and it acted as a bombshell in the camp of the Aristotelians.

On the other hand, there were the defenders of the new rationalism (from *ratio,* "reason") of whom Descartes was the inspiring genius. The word "new" is used significantly because the Aristotelians, entrenched in the churches and colleges, whatever may have been their failings, were themselves defenders of reason. To them, indeed, empiricist and new rationalist alike owed the ideal of consistency. But the scholastic mind had become cluttered with endless hair-splitting and with a slavish clinging to the letter rather than to the spirit of Aristotle's texts, so that Aristotelianism, for the time at least, had outlived its usefulness.

It is little short of astonishing how the champions of Descartes, illustrious and legion for more than a century, have been forgotten. One suspects that few of the following names will be familiar. There were physicians like Regius (Henry de Roy or Le Roy), at Utrecht, who after 1639 became Descartes' foremost representative in Holland, the first country to receive hospitably the new philosophy; Louis De La Forge, professor at the university of the French Protestants at Saumer, though himself a Catholic; and the Neopolitan Giovanni Alfonso Borelli (1608–1679), the most gifted of the Cartesian physicians and physiologists in Italy. There were also many physicists. The names of a dozen could be gleaned from a history of Cartesianism. Least unfamiliar will be Jacques Rohault (1620–1675), translations of whose work were used at Cambridge until the books of Newton made them obsolete; and Cardinal Gerdil (1718–1802) whose treatise was one of the last and ablest of the defenses of the Cartesian physics.

Descartes was not neglected even by the poets. Expositions of the new system were written in verse by Abbé Genest (1639–1709) and by Benedetto Stay (1714–1801), Latin poet, born at Ragusa, who become secretary to three Popes. But the master influenced literature in a subtler way. His *Discourse on Method* was the first philosophical work to reveal the clarity and precision of the French vernacular. French literature of the classical period, under the spell of Descartes, became concerned with exhibiting the excellence of reason in human conduct, in contrast with the emotions.

The prestige of Cartesianism affected the law. There was Henri François Daguesseau (1668–1751), Chancellor of France, who was so zealous a French patriot that he refused to license the publications of the Newtonians. In the eighteenth century, indeed, it grew to be a matter of patriotic duty as well as philosophic truth that loyal Frenchmen should champion Cartesian rationalism at the expense of British empiricism. One suspects that patriotic fervor sometimes was the stronger motive. An achievement of Voltaire, showing his extraordinary openmindedness, was that he dared defend Newton in France.

Indeed, the Cartesians, although at first they suffered persecution at the hands of the conservative Aristotelians, whether Catholic or Protestant, ended by becoming powerful in science, philosophy, literature, law, theology, and education. Seldom in modern times, unless one considers the wide cultural influence of Darwinian evolution, Marxism, and the Freudian psychology, has an intellectual movement pervaded so many departments of life. The wonder is that its power fell as rapidly as it did before the attacks of the empiricists.

With these preliminary remarks we are ready to look at the Cartesian method. In order to understand the Cartesian method it is important to remember that Descartes was above all a mathematician. Applying algebraic means to geometrical analysis he systematized what we now call Analytic Geometry. It was really the method he used in these studies that he tried to generalize into a method for all scientific inquiry.

Since the Cartesian procedure grew out of mathematical study, the scientists who favored him were armchair thinkers rather than mechanics. They needed no other equipment than a quill, a ream of paper, and some ink to unravel from their minds any amount of closely knit reasoning.

The four rules of method which the master gave in his *Discourse* at first glance seem

trivial. The basic one concerns the criterion for selection of the ideas which we should hold:

> Not to accept anything for true which I did not clearly know to be such; that is to say, carefully to avoid precipitancy and prejudice, and to comprise nothing more in my judgment than what was presented to my mind so clearly and distinctly as to exclude all ground for doubt.

We should accept only ideas that are obviously true. This rule in a laboratory would be inane. The laboratory assistant is not concerned with what he knows, but with the precision of his instruments and the accuracy of his recordings. The advice does, however, pierce to the point for the sheer thinker who is marshalling axioms and definitions to prove a geometrical theorem.

The remaining rules also are the report of technique by a case-hardened mathematician. His advice concerns analysis of a theorem to be proved into its parts, order of steps in proof, and exhaustiveness:

> To divide each of the difficulties under examination into as many parts as possible and as might be necessary for its adequate solution. . . . To conduct my thoughts in such order that, by commencing with objects the simplest and easiest to know, I might ascend by little and little, and, as it were, step by step, to the knowledge of the more complex; assigning in thought a certain order even to those objects which in their own nature do not stand in a relation of antecedence and sequence. . . . In every case to make enumerations so complete, and reviews so general, that I might be assured that nothing was omitted.

A mathematical student will be aware that these rules involve an important factor not explicitly mentioned. This is the use of intuition ("clear and distinct ideas"). In the end one depends upon intuition for the discovery and choice of axioms, for the shrewd breaking-up of the problem into parts, and for the efficient and solution-conducive order in steps of proof. There are no rules for guiding intuition. Practice helps, but if one does not have happy intuitions one will be inept even at mathematics of high-school grade.

Intuition is the key word of the Cartesian method. If Descartes and his followers had confined their "clear and distinct ideas" to mathematics, the struggle between the right and left wings of the scientific party would never have occurred. But Descartes had other intuitions. Sitting in his armchair he became aware of the essence of matter: Matter = extension. This proposition appeared to him with all the certainty of the proposition that the straight line is the shortest distance between two points. He toyed with his intuition of matter, passing on to other "clear and distinct ideas." A vacuum is an impossibility. If matter = extension, an extension which is not matter is absurd in the same utter way as a plane area bounded by three sides which is not a triangle. An atom (in the classical sense of least reducible particle) is an impossibility, because extension is precisely that sort of thing which can be halved indefinitely.

Conceiving of motion as a push applied to matter at the Creation, Descartes developed his Theory of Vortices or whirlpools in matter. By this conception, analogous perhaps to some forms of the modern electron theory, he tried to explain all physical phenomena: the motions and genesis of the heavenly bodies, the nature and transmission of light, weight, physiological and biological processes, and the existence of apparently discrete bodies like stones, blades of grass, the sun, comets, and planets. The Theory of Vortices, in short, played the same role in his natural philosophy as the atomic theory has in others.

An additional intuition about motion was that, since the primal "push," it has been constant. Transfers take place, but no motion has ever gone out of existence and none ever has or will come in. This is the Principle of the Conservation of Movement.

In this process of moving from one clear and distinct idea to another, Descartes devised his own laws of motion which stand in curious contrast to those of Newton. The Frenchman's primary laws of motion were: I, each thing perseveres in its state until a new cause supervenes which destroys it; II, no particle of matter ever tends to continue its motion in a curved line, but instead in a straight line; III, a body in motion which encounters another loses its determination, but not its movement. His seven secondary laws concern communication of motion, and are in error. Descartes made it impossible, finally, for his followers to adopt the popular conception of Newton's gravitation, according to which it is an occult force traversing

empty space. In the Cartesian world motion is transmitted only by contiguous bodies, so that force playing upon objects at a distance is unthinkable.

The first reaction one has to this array of speculation is a lively impression of its author's genius. Descartes was the creator of a technique in thinking by which he was able to give the world a new branch of mathematics, a new physics, a new cosmology, and a new physiology. But how successful was the Cartesian method? How much of this new science is true? Here praise must be qualified. The mathematical contribution was sound and was a preliminary to the invention of the Calculus by Newton and Leibniz. The general intuitions, moreover, were fruitful: that matter is of one kind throughout the universe; that there are laws of nature according to which all motions take place; and that all physical happenings, including physiological and biological processes, are explainable in terms of matter in motion. These constituted a platform shared by Galileo and his partisans as well as by the Cartesians, and for three centuries the insights have proved of indispensable worth to scientific enterprise. But when we come to evaluate the specific contributions of the Cartesians to science, we must admit that aside from Analytic Geometry, the Principle of the Conservation of Movement, and the insight that air has weight, there were perhaps none—nothing to compare with the host of laws discovered by Galileo, Boyle, Kepler, and Newton, and no specific invention to revolutionize industry like the steam engine of Watt.

Why did the Cartesian method fail? It worked in mathematics. Why should it not also have worked in the other sciences? We still have enough of the Cartesian left in us to imagine proudly that the universe is arranged according to our mathematical ideas, and that if we could grasp the true axioms and other basic concepts, we could unravel the laws of nature without having recourse to experiment and observation. Galileo himself had some of this bravado; he liked to boast occasionally that he used experiment to prove to those less wise than he what he already knew. But the unfortunate fact remains that we are never quite certain whether our mathematical reasoning holds true of nature; whether our axioms are true; or whether our definitions are not conventions of language rather than statements about things. Indeed, we are not even certain that the universe is wholly rational, that is, open in its uttermost depths to the pure reasoning powers of us puny mortals. This uncertainty infecting our minds when we reason about things not created by our reasoning is one of the causes for the failure of the Cartesian method.

The question of the inadequacy of the high a priori road in science is too difficult to be disposed of here. History will bear us out if we restrict ourselves to the modest assertion that the technique of pure mathematics is not enough when the thinker seeks to decode the laws of physics, chemistry, physiology, or of any other science treating of things in the physical world and presumably independent of our personal reasoning habits. The thinker must quit his armchair and go into the laboratory where there are vernier scales, clocks, lenses, and other instruments to refine and augment the powers of the senses. There he must ignore, as much as possible, what his reason tells him ought to be, and allow his judgment to be molded by facts largely alien and uncontrollable. Like Galileo he must study things in the same way as does the carpenter or plumber. His workshop has little in common with the snowbound hut where Descartes had his vision of the basis of true science.

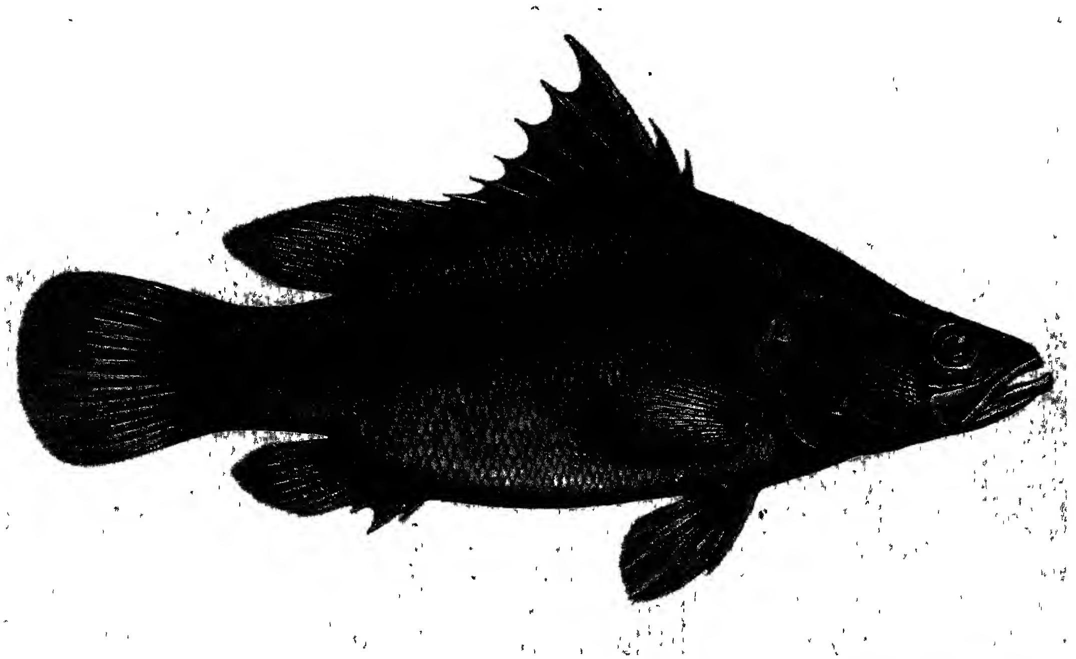
# THE GIANT FRESHWATER PERCH OF AFRICA

By E. W. GUDGER

Africa, that dark continent of great lakes and mighty rivers, lying under the tropic sun, has many ichthyological rarities. Like its neighbor across the Atlantic, it is a continent of catfishes. Boulenger, the great authority on African fishes, states that there are about two hundred species of Siluroid fishes in its waters. So far as I know, no one has estimated the number of species of these fishes in South American rivers. But as I have shown elsewhere, there are surely three and possibly thirteen kinds of giant catfishes in these rivers. On the other hand, Africa, with physical conditions very much the same, might be expected to produce a whole flock of great Siluroids; but for some unknown reason, it has not produced even one catfish worthy of mention because of its size.

Indeed, Africa's only giant freshwater fish is a percoid, *Lates niloticus*, the Nile perch. However, it is literally a giant perch, reaching a length of six feet. Its distribution is a curious one. Although found throughout the Nile from Lake Albert to its mouths, the Nile perch is not peculiar to the Nile, but is found also in the large western-flowing rivers —the Senegal, Niger, and Congo. For some unknown reason, it is absent from the Zambesi and other South African rivers. As we shall see, it has long been known in the Egyptian Nile and its portrait was painted in remote antiquity.

The Nile perch is not only the largest freshwater fish in Africa, but also the largest freshwater percoid in the world. Large specimens run ordinarily to 4 or 4½ feet in length. At the Sports Club in London there was recently a preserved (mounted?) specimen of a Lates whose weight was given as 253 pounds. It was said to have been caught in Lake No, at the junction of the Bahr el Ghazal with the Bahr el Jebel or Nile proper. Another from Lake No is said to have weighed 280 pounds. Lortet and Gail-



*After Boulenger, 1907*

FIG. 1. THE NILE PERCH (*LATES NILOTICUS*)
THE LARGEST FRESHWATER FISH OF AFRICA AND LARGEST FRESHWATER PERCOID IN THE ENTIRE WORLD.

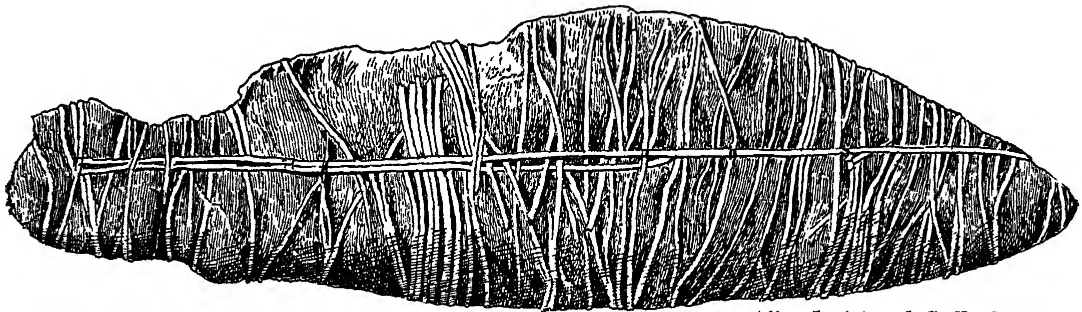
lard (*Archives Museum d' Histoire Naturelle de Lyon*, 1903, Vol 8, pp. 185–190) measured one 71 inches long, and state that they had seen caught at Assuan several individuals over two meters long—probably more than 80 inches overall; but they do not say that they actually measured these specimens. At the time of the publication of his book, *The Fishes of the Nile* (1907), Boulenger gives as the attested record Lates known to him, one taken a few miles up the Sobat River, the most southern Nile tributary from Abyssinia, in about 9° N. Lat. This great perch was 73 inches in length, 55 inches in girth, and weighed 266¾ pounds.

Little is known about the natural history of this splendid fish, which is beautifully portrayed in Boulenger's drawing (Fig. 1). Efforts made at Cairo to keep large specimens in the Aquarium were not successful; they fed ordinarily on live fish but lived only a few days or at most a few weeks. However, some young specimens thrived and grew rapidly, often at the expense of their smaller and weaker brethren who mysteriously disappeared—evidently down the gullets of their stronger cannibalistic fellows. The word Lates is derived from the Greek word *latos*, the name for a perch-like fish of the Nile, and is now restricted to this particular form.

The ancient Egyptians were animal worshippers and it is interesting to note that they did not overlook the superb fish which we know as *Lates niloticus*. It was much venerated by them and its mummified remains, scattered throughout the valley of the Nile, are very numerous. There was a special cult of Lates at Esneh on the Nile in Upper Egypt (Lat. 25.4° N.), where it was worshipped as a divinity of the first rank, and for this reason, in Graeco-Roman times the town was called Latopolis—the city of the Lates fish.

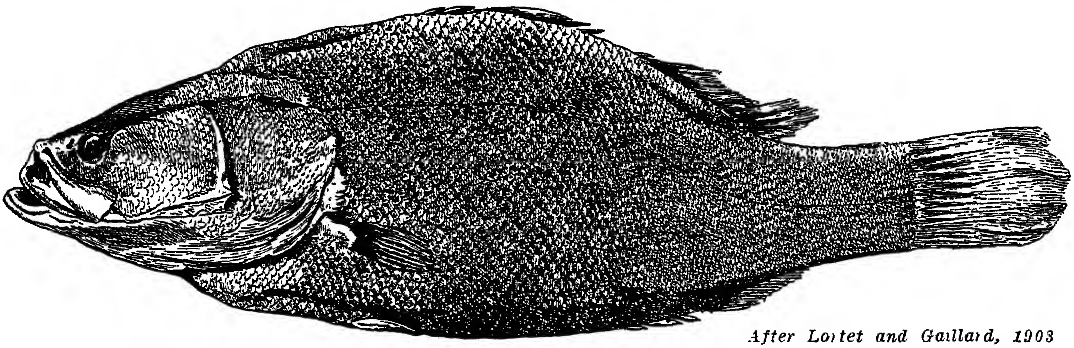
At Esneh, Lates mummies have been found in great numbers buried at shallow depths in a sandy plain near the town. Examination of these mummies showed that the large specimens had each had an abdominal incision made to permit easy entrance of the mummifying solution Then each fish had evidently been subjected to prolonged immersion in a strong brine from one of the Egyptian natron lakes, but there was no evidence of the use of asphalt or bitumen. (This was ascertained by making a chemical analysis of the flesh of the fish and of the wrappings.) Next the fish was swathed in linen cloths, and these were secured by many circumferential windings of cord. These in turn were held in place by a longitudinal cord (Fig. 2). The curing in pickle may have been done after the fish had been wrapped. Finally, the mummified fish were buried in the dry sand.

Thus prepared and buried, these mummies in the dry air and dry sand of Upper Egypt have "kept" perfectly and when exhumed after twenty-five centuries are found, according to Lortet and Gaillard, to possess almost as much animal matter as dried codfish in our markets. Figure 3 shows what was found when the wrappings (seen in Fig. 2) were removed, and when the dried salty slime in which the fish had been pickled had been wiped off with a damp cloth. This fish has been marvelously preserved. Note not only the splendid form of the body, but the wonderfully preserved scales and lateral line, the



*After Lortet and Gaillard, 1903*

FIG. 2. MUMMIFIED SACRED FISH, LATES, EXTERNAL VIEW
FROM ESNEH, UPPER EGYPT. SHOWING LINEN SWATHINGS AND LASHING CORDS THAT FORM THE MUMMY CASE.

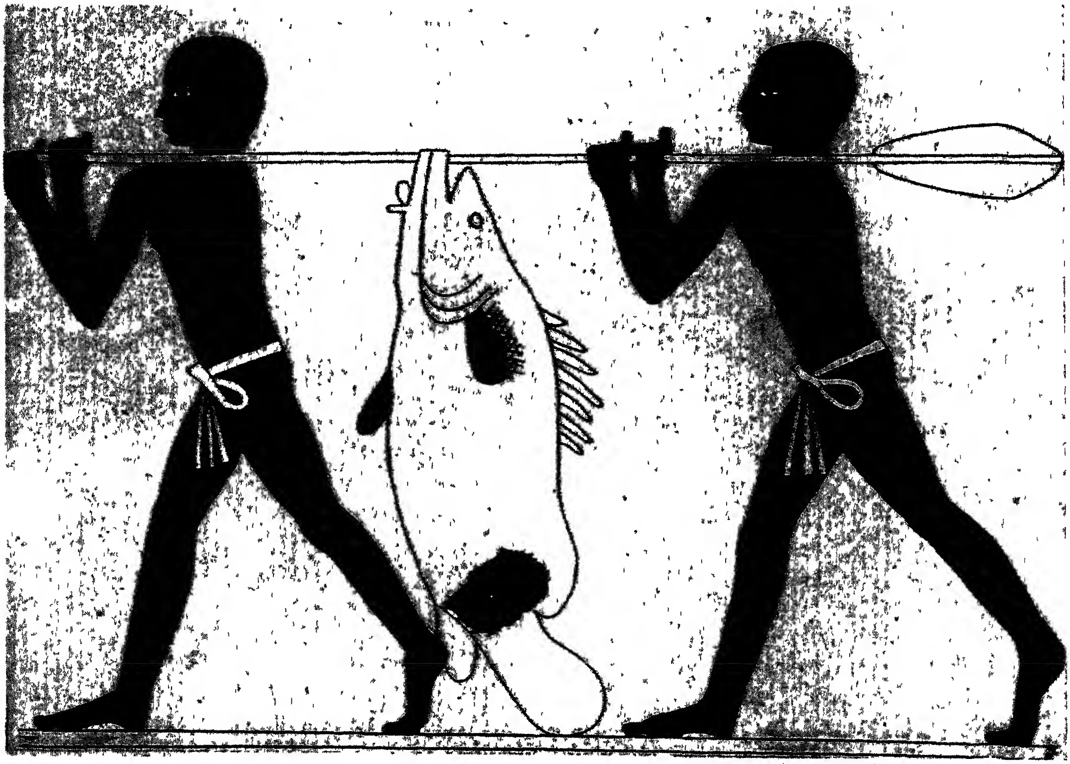


*After Lortet and Gaillard, 1903*

FIG. 3. MUMMIFIED LATES UNWRAPPED AND CLEANED OF DRIED SALTY SLIME
THIS FISH HAS BEEN PERFECTLY PRESERVED, EVEN WITH SCALES, FINS, AND EYEBALL, FOR 25 CENTURIES.

fin-rays, and membranes. Most notable of all is the fact that even the very eyeball is intact. Many such finely preserved specimens were about five feet long.

There is a large animal cemetery at Gurob on the border of the district of the Fayum on the west bank of the Nile about sixty miles south of Cairo. Fifty burial pits here were exhumed by L. Loat and reported on in 1904 (*Egyptian Research Accounts*, X, p. 3). From these pits, Loat obtained remains of scores of Lates. Unlike the Lates at Esneh, these were not mummified, but were sometimes wrapped in bundles of grass, or covered with ashes obtained by burning the grass. Various animals were buried here but the Lates' remains predominate. Over and over Loat notes "no preservative." The fish were wrapped in grass, partially covered with ashes, or laid down as caught. Not



*From Flinders Petrie, pl. XII, 1892*

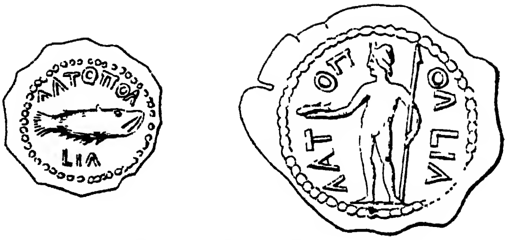
FIG. 4. A NILE PERCH CARRIED ON THE HANDLE OF A BOAT PADDLE
FROM A PAINTING ON THE SOUTH WALL OF THE TOMB OF THE PRIEST, RAHOTEP, AT MEDUM IN LOWER EGYPT.

being mummified, the flesh has gone, leaving only the loose bones, or sometimes rather complete skeletons, as Loat's photographs show. In the photographs, sometimes the outline of the fish's body shows quite plainly. Study of these remains of large fish showed that the abdomen of one had been opened (the vital organs probably removed) and the cavity filled with ashes, while the mouth and gill openings of another large specimen had been filled with ashes. This looks as if some attempt had been made to use ashes as a help in preservation, but Loat repeatedly notes "no preservatives"—such as was used on the Esneh fish. Desiccation and slow oxidation have left nothing but the hard parts. The rough outline of the body in some cases (as shown in Loat's photographs) is probably due to the scales on the under side of the body remaining somewhat intact. Thus one fish, it is said, measured "5 feet 6 inches long, and nearly 2 feet in depth."

These remains of Lates ranged from small to large. Loat repeatedly speaks of large specimens, and for the better preserved fish gives measurements: 5 feet; 5 feet and 2 inches; 5 feet 6 inches (2 specimens, one "nearly 2 ft. deep"); and last of all, "one large fish, nearly 6 ft. long." From this one must not conclude that Lates grew larger in olden days, but that the fishery then was probably less efficient than today and the fish had a better chance to attain full growth.

It is interesting to note that in contrast to burial pits for oxen and goats at Gurob, the pits for fishes were more carefully dug, and in many cases only a single fish was found in each pit. If two or more fish were buried together, a certain order was observed; either they were laid side by side, or head to tail, or placed in layers, and in no case was any other fish or animal species found with Lates. These things indicate the great reverence in which the fish was held.

Paintings of Lates are found on the walls of various tombs in Egypt, particularly on those of Medum, which is on the left bank of the Nile between the river and the Fayum, about fifteen miles north of Gurob. On the south wall of the mastaba (or tomb) of



*Figs. ×2 from Russeger's Reisen, 1846*

FIG. 5. GREEK COINS OF LATOPOLIS

ANCIENT COINS SAID TO PORTRAY THE NILE PERCH.

Rahotep, high priest of Heliopolis (the city of the Sun), is an easily recognizable representation of the Nile Perch (Fig. 4). Here a large specimen of Lates (apparently about 5 feet long) is carried on the long handle of a paddle supported on the shoulders of two men. This figure closely resembles the one drawn for Boulenger. Even seven of the nine dorsal spines are shown, the eighth and ninth being so incorporated in the soft dorsal fin as to be easily passed over. According to an Egyptologist, the Medum Lates was painted about 2780 B.C.; thus it is probably the oldest figure of a fish of historic times.

But the Egyptians were not content with portraying the fish in a painting. Boulenger writes that in 1899 he was shown ". . . a bronze model, 115 millimeters long, which at once suggested to me a young *Lates niloticus*. This model contained a mummy of a small fish, the loose bones of which I have been able to examine and to identify as those of a young Lates."

Boulenger states that, on certain ancient Greek coins of Latopolis, there are representations of a fish which he and Russeger recognize as Lates (Fig. 5). It is noted by Russeger, from whom the figures of the coins are copied, that on the reverse side of each coin is found an effigy of Hadrian, the Roman emperor whose reign covered the years A.D. 117–138. This establishes the fact that these coins were minted more than 1800 years ago. However, a mere glance shows that the artist, who cut the figure of the fish on the dies from which the coins were struck, was not in the same class with the painter who depicted Lates on the wall of the tomb of Rahotep at Medum, thousands of years earlier.

# USING HYDROGEN TO SAVE COAL

By PHILIP L. ALGER

When one passes a high voltage substation where electric power lines meet in a forest of steel towers and insulators, one may see a large steel cylinder with rounded heads. Such a cylinder is probably the housing of a hydrogen-cooled synchronous condenser—a high speed generator of reactive electric power, rotating in a sealed tank of ninety-seven percent pure hydrogen (Fig. 1).

The first of these machines went into service in Pawtucket, Rhode Island, in 1928, but for seven years before that time they had been under development, and during the fifteen years that have followed, their use has continued to increase. Now they have become an important factor in meeting the war demands for electric power that have threatened to exceed the country's capacity to meet.

It would be difficult to find a better example than the hydrogen-cooled generator of the birth of an idea in the atmosphere of pure science and its systematic and persistent development by cooperative effort into a reality of great practical importance. In 1921, Dr. Willis R. Whitney, Director of the Research Laboratory of the General Electric Company, wrote a note (Fig. 2) to one of his young research assistants, Chester W. Rice. That note started a long train of events, the consequences of which are not yet fully developed. Two results are that more electric energy than was thought possible is being produced from given amounts of copper, steel, and other critical materials in the generating equipment on the one hand, and from given amounts of coal or oil fuel on the other hand. It has resulted in the saving of not less than one hundred and fifty thousand tons of coal during 1943 in the production of electric power in the United States. Since this saving will continue and greatly increase, it will postpone the time when our coal mines will be exhausted.

Dr. Whitney's question arose because as larger and higher speed generators were made, the heat dissipation and power loss associated with churning up such a heavy ventilating medium as air were becoming serious. But the idea of using a lighter gas did not solve anything—it merely opened up a whole series of other questions, such as:

What properties of a gas would be best for cooling electric generators?

What gas provides the best compromise between windage losses and cooling?

What will be the effects of this gas on electrical insulation?

Is a gas-tight enclosure, including shaft sealing, practicable for turbine driven generators?

How about explosion risks if hydrogen is used?

What about filling and emptying procedures, operating controls, and the auxiliary equipment required?

Will the benefits justify the increased production costs, not to mention the cost of development?

Before a practicable result could be anticipated, it was evidently necessary to answer these questions, and a lot more that would certainly be uncovered later. Chester Rice started, therefore, by making an intensive investigation of the free and forced convection cooling properties of gases. Early in this study he found that gas viscosity is a factor of the first importance in heat transfer properties, and he was thus led to build on Langmuir's stagnant film theory, which reduced the hopelessly complex convection problem to one of heat conduction in the steady state. Langmuir's earlier application of the laws of conduction, radiation, and convection, derived from his film theory, enabled him to more than double the efficiency of the incandescent lamp. Rice extended these laws by the method of dimensions to cover the analysis of the cooling of rotating machines, and he conducted a great number of experiments on numerous liquids and gases to determine practicable working formulas. He found that hydrogen, with seven percent of the density of air, has seven times as much heat conductivity, fourteen and five-tenths times as great specific heat, and a

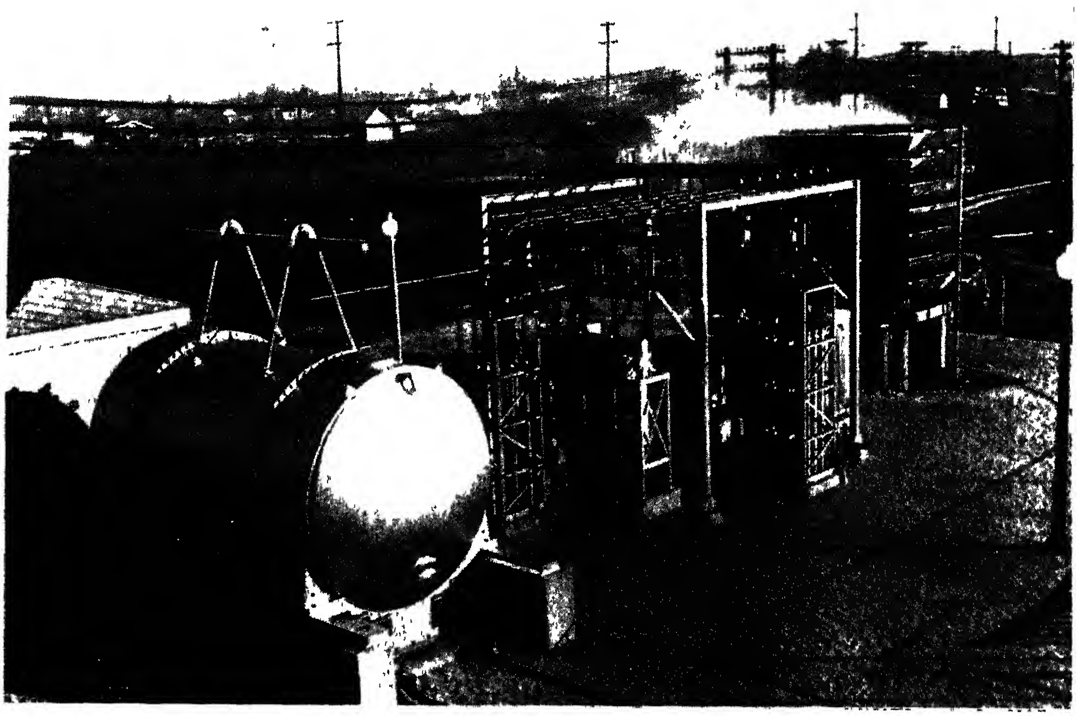


FIG. 1. OUTDOOR SUBSTATION
WITH HYDROGEN-COOLED SYNCHRONOUS CONDENSER, 30,000 KVA, 11,500 VOLTS, 60 CYCLES, TYPE TSC–GL.

thirty percent greater coefficient of surface heat convection, making it clearly superior to all other gases for minimizing both the cooling and windage losses.

His results were presented before the American Institute of Electrical Engineers and published in a fifty-page paper in the *Transactions* for 1923. The interest of engineers being thus aroused, a 6,250 kilovolt-ampere turbine generator was built, and was run in hydrogen for extended periods. This work showed that hydrogen gave the anticipated results so far as cooling and windage losses were concerned, proving that roughly twenty to twenty-five percent greater electrical output could safely be obtained from a machine of given dimensions if operated in hydrogen instead of air. This opened up a new train of development, as it suggested that steam turbine driven generators of 25,000 kilowatts and larger could be built to run at 3,600 instead of 1,800 revolutions per minute. Such an increase in speed would make possible large increases in steam turbine efficiency.

Numerous measurements were made of temperature rise and windage losses under different conditions; and twenty-five explosions were set off in the generator with different mixtures of air and hydrogen. On the basis of heat content, ignition of the most explosive mixture of air and hydrogen (about five parts of air and two of hydrogen) should develop a pressure of about one hundred and eighty pounds per square inch. The tests showed, in fact, that explosion risks could be discounted because the maximum pressure recorded over the full range of mixtures was forty-five pounds per square inch However, later tests on a 12,500 kilovolt-ampere synchronous condenser frame, before the rotor windings or coolers were installed, developed a maximum instantaneous pressure of eighty-five pounds per square inch. Frames are readily designed to withstand even these pressures.

Meanwhile, tests of eight thousand hours' duration were being conducted on electrical insulation exposed to high voltages in air and hydrogen. These demonstrated that corona, due to dielectric stresses exceeding the ionization potential of the gas, causes

very little damage to organic materials in hydrogen, whereas in air rapid deterioration occurs. Furthermore, in the absence of oxygen, the damage due to an electrical failure is normally confined to only a few coils, whereas with open type air-cooled machines a fire may spread with great rapidity and damage the entire winding beyond repair. These conclusions gave hope for materially greater insulation life and reduced maintenance in hydrogen-cooled machines.

All these results were reported to the American Institute of Electrical Engineers in 1925, arousing much discussion and stimulating others to conduct similar investigations. Thus at an early stage in the development of the invention not only the original inventor but others were actively at work on both theory and experiments. This open publication and the discussions of both theory and experiment long before any financial returns had been received were possible only because the inventor was protected by a patent under the American patent system. In 1923, also, a United States patent was issued to Max Schuler on the basis of claims filed in 1916; this patent was purchased by the General Electric Company.

While the engineers were experimenting with a full-sized generator, Rice made an ingenious revolving disc apparatus in a bell jar for measuring windage losses in different gases. With this apparatus he carried out experiments with air, hydrogen, and carbon dioxide at different atmospheric pressures. These experiments verified the proportionality of windage losses to gas density and gave valuable information on the design of ventilating fans for hydrogen circulation. Rice reported these experiments in the May, 1925, issue of the *General Electric Review*.

The question of how to prevent hydrogen leakage through the bearing clearances on a large turbine generator shaft now appeared as the limiting feature of design. To provide for an adequate thickness of oil film in the bearing for both load carrying and cooling purposes, it is necessary to have a radial clearance of the order of one thousandth of an inch per inch of diameter without which a prohibitive leakage would occur in the absence of a seal. Research work during the next two years was concentrated on this problem, when the inventor developed a satisfactory liquid film seal. Vacuum-treated oil was pumped into an annular groove in a babbitted sealing ring dividing it into two streams flowing in opposite directions along the shaft, and draining it into two independent detraining tanks. The hydrogen absorbed by the oil on one side, and the air absorbed on the other side, are partially given up in these tanks, and the oil is then vacuum-treated to remove the remaining air and hydrogen, cooled and pumped to the seals. Many variations from this seal have since been developed, but in general the basic liquid film features have been retained. This work was also published by Rice in the *General Electric Review* (Nov. 1927).

Further consideration of shaft sealing auxiliary equipment, coupled with some practical doubts concerning explosion risks in large power stations, deflected the engineers during the next few years to the study of synchronous condensers. Since these machines are operated as idling synchronous motors, neither driving nor being driven, they do not require any shaft seals. Further, they are usually located at outlying substations where any explosion damage would be inconsequential. Consequently, effort was devoted to frame structures, hydrogen-tight welds and gaskets, and new designs to take advantage of the better cooling afforded by hydrogen. It was then found that the hermetically sealed frame designs were ideally adapted to outdoor operation, with consequent saving in building expense and reduced explosion risks. At last two hydrogen cooled condensers, of 12,500 and 20,000 kilovolt-amperes rating, were ordered in 1927 and were put into operation in June and December, 1928.

This advance was reported to the American Institute of Electrical Engineers by R. W. Wieseman in 1929. In the next few years, large numbers of these machines were installed, the total kilovolt-ampere capacity in service reaching 161,000 on the American Gas and Electric Company system alone by 1939, and the total of all those shipped by General Electric reaching 593,000 kilovolt-amperes in 1943. Reduced windage losses in these machines are believed to save annually the equivalent of 25,000 tons of coal.

Received about
Feb 21, 1921
C.W.R.

Dear Chester

Could I create an interest for you in a series of fool stunts which have, I think, the promise in them of some useful returns.

I'd like to study experimentally (not on paper) because I expect the unexpected when we deal with such a complex subject. and this is it.

I want to take a motor-generator set and enclose it gas tight. replace the air with Hydrogen and run the thing. When this is done I want to see what the effect was (not before) I want to know whether it ran (1) easier (friction against gas skin friction) (2) cooler because of thermal conductivity of the Hydrogen (3) safer for the insulation because it might stand higher temperature in $H_2$ than in $O_2$ without decomposition safer because it might arc less and electrically break down less easily because in $H_2$ arcing distances are greater (4) Perhaps the speed attainable economically would go up with the $H_2$ and speed, in such things as turbine alternators & alex. machines is important This might all lead to substitution of $H_2$ by $CO_2$ or vacuum, but it could hardly be carried thru a series of practical tests without adding a lot to our knowledge and might find a real useful application Don't worry about cost of the leakage or danger I've got that done except cheaply

Whitney

FIG. 2. ORIGINAL LETTER FROM DR. WILLIS R. WHITNEY TO CHESTER W. RICE IN THIS WHITNEY SETS FORTH THE PROPOSED INVESTIGATION OF HYDROGEN-COOLED ELECTRIC GENERATORS.

A 24,000 volt synchronous condenser has been operating in hydrogen since 1931 without any insulation difficulty. Since both oil and insulation remain fresh and clean in the hydrogen atmosphere, routine inspections of these machines are usually made at only five-year intervals, the hydrogen seals being unbroken meanwhile.

The success of hydrogen cooling for condensers led to renewed studies of generator designs and shaft seals, but the onset of the economic depression delayed actual construction until 1936. The first commercially operated hydrogen-cooled turbine generator, of 25,000 kilowatt rating and 3,600 revolutions per minute, went into service at Millers Ford Station in Dayton, Ohio, in October, 1937, as reported in the May 7, 1938, issue of the *Electrical World*. A general report on the operation of four of the earliest hydrogen-cooled generators was made by E. H. Freiburghouse and D. S. Snell in August, 1938, after the latter had spent several very arduous weeks in putting the pioneer installation into shape for operation. The curve in Figure 3 shows the rapid increase in shipments of these generators since that time, reaching a cumulative total for the General Electric Company alone of 3,878,000 kilovolt-amperes by the end of 1942.

By inspection of Figures 4 and 5, some realization of the technical problems involved in this development can be gained. The body of the 60,000 kilowatt generator rotor in Figure 4 is a one-piece alloy steel forging some thirty-six inches in diameter and thirty tons in weight that has been put through a carefully controlled heat treating cycle of several hundred hours duration. It is slotted to receive a two-pole field winding of strap copper or aluminum, whose ends are held in place by high-strength alloy steel retaining rings. The peripheral velocity of the rotor surface is of the order of six miles per minute, and the kinetic energy of the entire mass, when revolving at normal speed of 3,600 revolutions per minute, is some sixty-five thousand foot tons, or fifty kilowatt hours. The pressure developed by the rotor fans is roughly equivalent to twenty inches of water for air or two inches for hydrogen, and the windage and fan losses are about 900 kilowatts for air and 90 for hydrogen. To reduce these losses, it is usual to use external fans for the large air-cooled machines. The total losses exclusive of windage are about 550 kilowatts, so that the use of hydrogen raises the generator efficiency from 97.5 to 98.7 percent. Figure 6 shows the outline dimensions of two 50,000 kilovolt-ampere generators, one designed for air and the other for hydrogen cooling.

TABLE 1

CUMULATIVE SAVING OF COAL FOR GENERAL ELECTRIC GENERATORS

| Year | Cumulative total equipment shipped | Cumulative saving of coal |
|---|---|---|
| | *KVA* | *Tons* |
| 1937 | 258,000 | 0 |
| 1938 | 730,000 | 8,000 |
| 1939 | 1,067,000 | 30,000 |
| 1940 | 2,061,000 | 62,000 |
| 1941 | 2,737,000 | 124,000 |
| 1942 | 3,878,000 | 206,000 |
| 1943 | | 322,000 |

In designing large generators making 3.600 revolutions per minute, it has been found desirable in many cases to use aluminum field windings, the light weight of the aluminum more than making up for its poorer electrical conductivity. In this way, larger rotor diameters are permissible with-

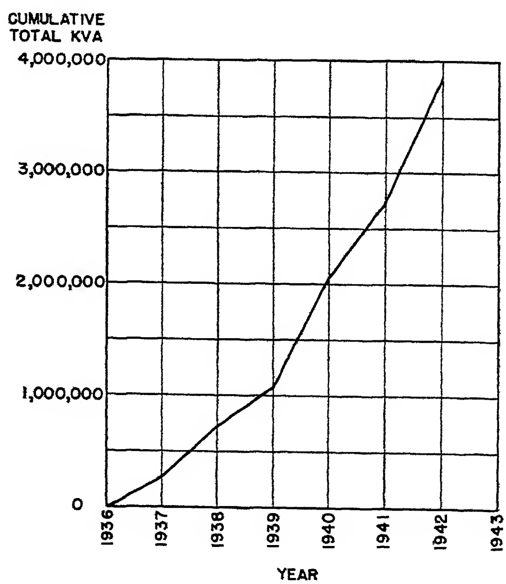



FIG. 3. HYDROGEN–COOLED GENERATORS CURVE SHOWING SHIPMENTS OF GENERAL ELECTRIC CO.

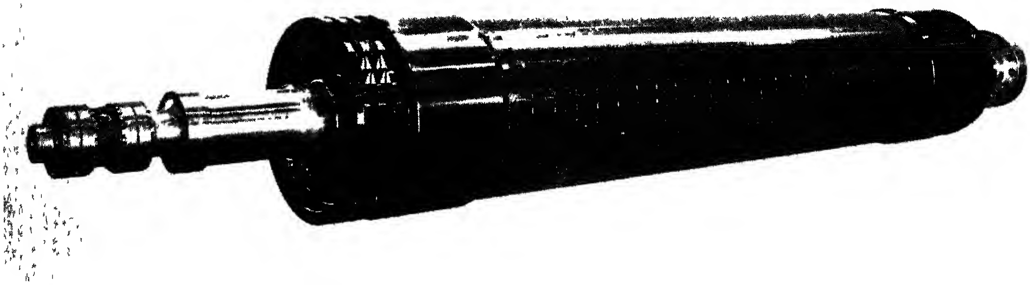


FIG. 4. WOUND REVOLVING FIELD FOR SYNCHRONOUS A–C TURBINE GENERATOR
81,250 KVA, 3600 RPM, 13,800 VOLTS, 60 CYCLES, TYPE ATB–HT, 2 POLE. OBLIQUE VIEW FROM FRONT END.

out exceeding the allowable centrifugal stresses. Hydrogen cooling is singularly well adapted for use with these larger rotors, since it obviates the serious disadvantage of very high windage losses, which would occur in air. Table 1 shows the cumulative saving of coal for General Electric generators alone.

These savings have been conservatively estimated on the basis of an improvement in generator efficiency equal to one percent of the kilowatt rating at all times that the unit is in operation. The saving is, of course, two percent of the output during half-load operation, or four percent at one-quarter load, since it is due to reduced rotation losses. It has been assumed that each kilowatt hour saving will save one pound of coal, and it has been assumed also that these new efficient hydrogen-cooled machines would operate 7,500 hours per year, or eighty-five percent of the time.

Considering machines of other manufacture and the synchronous condensers also in service, the saving in coal this year will exceed one hundred and fifty thousand tons, and higher values are indicated for all succeeding years.

The ramifications of this hydrogen cooling development are very numerous, and many of them are of great scientific interest. For example, in the oil sealing of the rotating shaft questions had to be settled regarding the rate of absorption of pure hydrogen and air by oil at different viscosities and temperatures, and the rate of detraining of

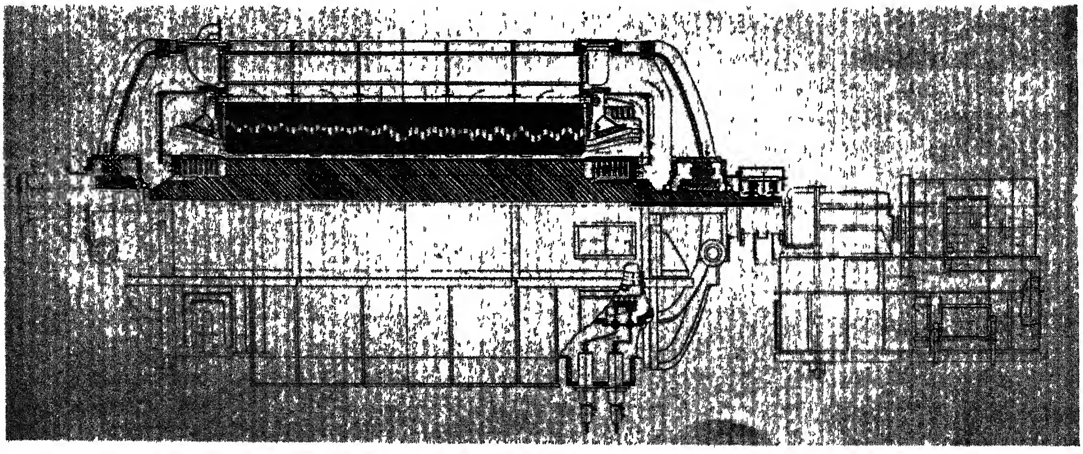


FIG. 5. HYDROGEN-COOLED A–C TURBINE GENERATOR
66,667 KVA, 3600 RPM, 11,000 VOLTS, 60 CYCLES, TYPE ATB–HT. VIEW OF LONGITUDINAL SEMISECTION.

these gases from the oil under various vacuum conditions. Also, extensive investigations were required of the properties of gas mixtures, ranging from pure helium, pure hydrogen, methane, and carbon dioxide through various mixtures of these gases with one another and with air. Pure helium, which has frequently been suggested as a substitute for hydrogen, would have a gas temperature rise thirty-five percent greater than that of the air-cooled machines, for the same rate of gas circulation and the same losses, the product of specific heat and density for helium being seventy-four percent of the value for air. While the reduced density of helium would reduce the windage losses to only fourteen percent of those in air, the disadvantage above mentioned and the higher cost have prevented its use in any machines built to date. Many problems also had to be solved in connection with the circulation of hydrogen through the ventilating passages of high speed machines, and the development of fans and hydrogen-to-water coolers.

When the first hydrogen-cooled machines were built, a major difficulty was hydrogen leakage through the welds. The Turner 20,000 kilovolt-ampere condenser built in 1928 lost initially 18,480 cubic feet of gas weekly, but the Scarboro 15,000 kilovolt-ampere machine of 1930 lost only 1,000; and in 1936, when the Fostoria 1,200 revolutions per minute, 30,000 kilovolt-ampere condenser was installed, its leakage was only twelve cubic feet per week. This latest machine was designed for operation in hydrogen at twice atmospheric pressure at twenty percent above its normal hydrogen-cooled rating.

The leakage from the largest present-day hydrogen-cooled generators, including seal losses, normally only amounts to a dollar a day, and only one hundred dollars worth of hydrogen is needed in order to place one of them in operation. It thus costs something less than five hundred dollars per year to supply and maintain the hydrogen atmosphere. For this five hundred dollars there is a direct saving of the order of ten thousand dollars worth of coal for a fifty thousand kilowatt generator. Today the lower limit of economic use of hydrogen as a cooling medium for steam turbine driven generators is about twenty thousand kilowatts, but indications are strong that this lower limit will be appreciably reduced in the years to come.

A secondary advantage obtained by this development is the reduction of noise, as is evident when one steps into the latest power stations. The windage noise of large high-speed air-cooled machinery, as regularly built a few years ago, is a steady roar, but

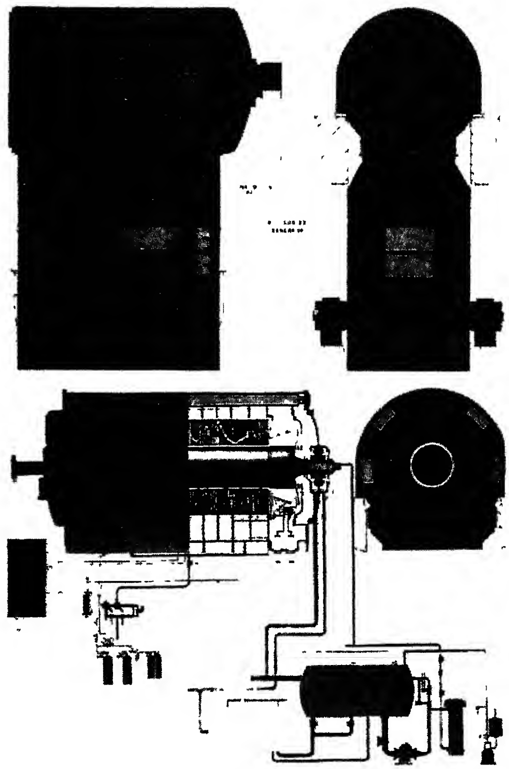


FIG. 6. COMPARATIVE OUTLINES OF AIR-COOLED AND HYDROGEN-COOLED GENERATORS.

when these machines are redesigned for operation with internal coolers and heavy steel wrapper plate construction, as for hydrogen cooling, they are so quiet that it is difficult to tell whether they are running or not.

Summing up this story, the end result of Dr. Whitney's note is that hydrogen cooling has become standard for nearly all large steam turbine driven generators in the United States. Because of this hydrogen atmosphere, they are more efficient than similar generators operating in air; they are

smaller in size; they are safer to operate; and they will last longer. The advantages demonstrated when the first of such generators was put in service by the Dayton Power and Light Company in October, 1937, were such that only four years later three-fourths of the turbine generators rated twenty thousand kilowatts and larger were being ordered with hydrogen cooling.

Considering the development as an example of the working of the American system of productive enterprise, it is important to note that at each step in the development the results of tests and calculations were reported to the industry and widely published. This brought in critical comments, which were helpful in guiding the further progress of the work, and stimulated work along alternative lines by research men and competitors. In the course of the work, many different organizations and hundreds of individual scientists and engineers participated, as recorded in more than fifty articles in the technical press.

In historical perspective, the story of hydrogen cooling provides a most interesting record of the free play of invention, publication, discussion, competitive rivalry, and commercial leadership that mark the American way of industrial progress.

At each major step in the hydrogen cooling program, it was necessary to expend large sums in advance of any provable return, and considerable risks had to be assumed. By and large, however, these costs have been borne by those to whom the financial return should ultimately come, while the manufacturers and operators who pioneered in making and purchasing the first machines of this radical new type have each assumed the risks that came within their proper spheres. As it has turned out, there has been no machine out of service because of failure directly chargeable to hydrogen cooling, and the once feared operating risks have proved to be negligible. The increased investment cost of hydrogen cooling has in all cases been paid off by fuel savings after a very short period of operation. The savings in coal, one of the most important natural resources, are cumulative and will eventually amount to enormous figures.

# A BOTANIST'S DOMINICA DIARY

## II. OFF THE BEATEN PATH

By W. H. HODGE

THE Caribbean islands are all geologically young, having arisen from the ocean floor as submarine volcanoes during the early Cenozoic. As a member of a chain of isles which can boast of such ebullient volcanoes as Pelée on Martinique and La Soufrière of St. Lucia, it is not surprising that Dominica still shows signs of active vulcanism. All her peaks are old volcanoes, and a few like Morne au Diable still possess wonderfully symmetrical cones, but present-day activity is limited to the numerous and widely scattered hot sulfur springs. The most striking of these is situated in the region known as the Grande Soufrière, an inaccessible basin hemmed in by mountainous ridges in the southeastern portion of the isle. Like all of Dominica's natural wonders, this Valley of Desolation—a half-day's trip from the little mountain village of Laudat—may be reached only by a rugged forest footpath known to few of the native woodsmen. For many years the exact location of the Grande Soufrière was unknown, and even today it is difficult to find a Dominican who has ever visited it.

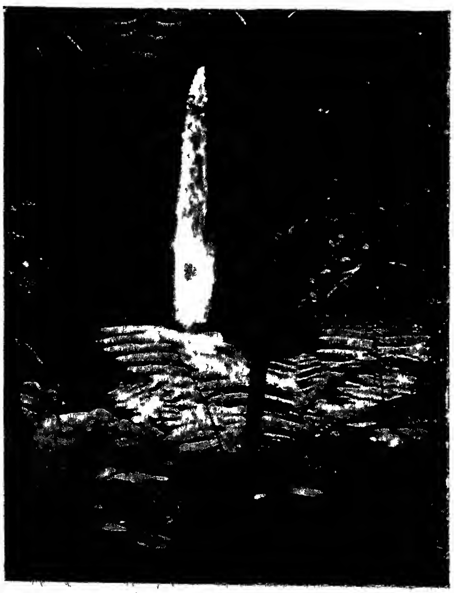
The first view of the basin is from the shrubby summit of the peak known as Morne Nicholls, down whose precipitous eastern slopes one must slide and slither in order to get into the small semicircular amphitheater of the valley. Scattered over the valley floor are numerous solfataras bubbling noisily and emitting steamy sulfurous vapors, which continue to arise from the hot streams as they pour out of these vents and rush easterly out of the valley's mouth. The incessant activity of the fumes, wind-blown over the whole extent of the valley, has eliminated much of

THE ROSEAU RIVER VALLEY LOOKING EAST FROM MORNE BRUCE
LIME ORCHARDS IN VALLEY BELOW DISTANT LAKE MOUNTAIN SITUATED HALF ACROSS THE ISLAND.

LOOKING SOUTH OVER THE SUMMIT OF MORNE TROIS PITONS
FIRST PHOTOGRAPH EVER TAKEN ON THIS SUMMIT. MOSSY FOREST CLOAKS ALL THE RIDGES. FAINTER PEAKS IN THE BACKGROUND ARE: GRANDE SOUFRIÈRE HILLS (LEFT); MORNE MICOTRIN BELOW IN FRONT. PROBABLY 400 INCHES OF RAIN FALLS A YEAR IN THE FOREGROUND BASIN.

an otherwise aggressive mountain vegetation, and almost the only plants existing in the vicinity of the fumaroles are tough grasses (*Ischaemum*) and creamy-flowered terrestrial bromeliads (*Pitcairnia*), while submerged in the sinter and travertine deposited by the hot waters grow various colorful algae.

The largest of these springs is the celebrated "Boiling Lake," hardly a lake but an impressive-looking basin, a hundred or more feet across, held in by twenty-five-foot walls. The waters, apparently not deep, are

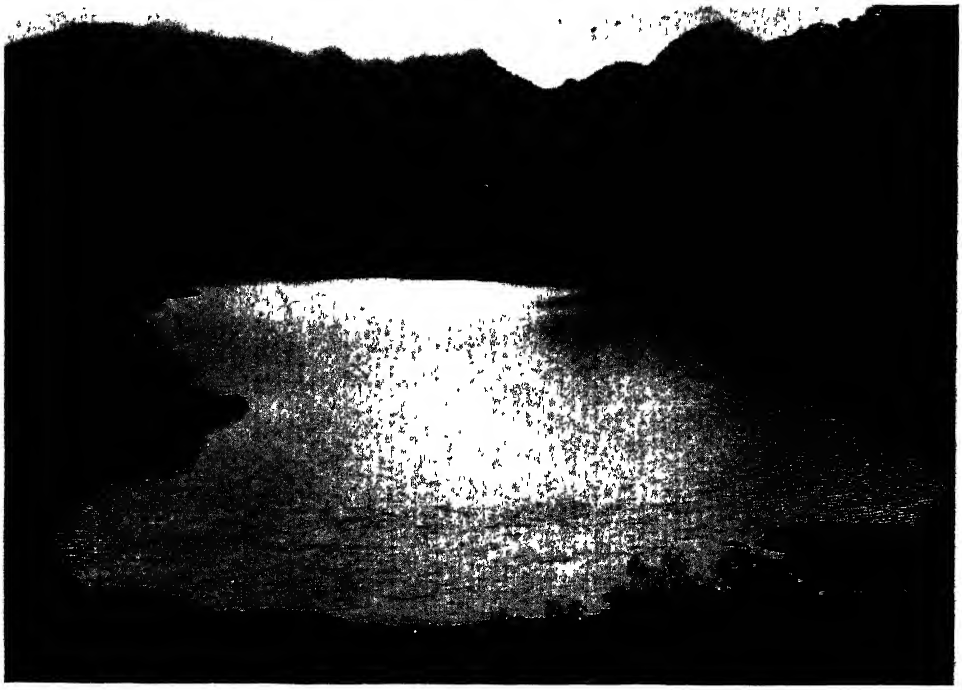


ROSEAU VALLEY WATERFALLS
BELOW LAUDAT VILLAGE. RUGGED TERRAIN AND HEAVY RAINFALL MAKE WATERFALLS COMMON.

in a continuous seething activity, and blanketing clouds of steam and noxious fumes (which have killed at least one visitor) hover continuously over the surface, making photographs almost impossible. Boiling Lake may represent either the remains of an old volcanic crater or a collection of large fumaroles whose outlet has been dammed by earth slides, thus impounding the hot water. In January 1880 a violent eruption took place in this vicinity; the last volcanic sign was a severe earthquake in 1906.

Laudat village makes a good base camp, for besides Boiling Lake, Dominica's only other "lakes" (as well as the peaks of Micotrin and Morne Watt) may also be reached from here. Freshwater and Boeri lakes, east of Laudat, are located in old volcanic craters, barely an eighth of a mile across; yet these very beautiful mountain pools are ranked by provincial islanders among the seven wonders of their tiny world.

It is sometimes hard to realize that Dominica was once a thriving Caribbean center, politically and strategically a threat to the French West Indian aspirations, and yet such was the case. Before the American Revolution broke out, Roseau, Dominica's capital, was a flourishing free port important to traders not only from the other West Indian islands but also from England and North America. Into this roadstead sailed the ships of Drake and Hawkins with cargoes of slaves destined for sale to the French and Spanish planters as well as to those American buyers who came from the colonies.



FRESHWATER LAKE NEAR LAUDAT VILLAGE

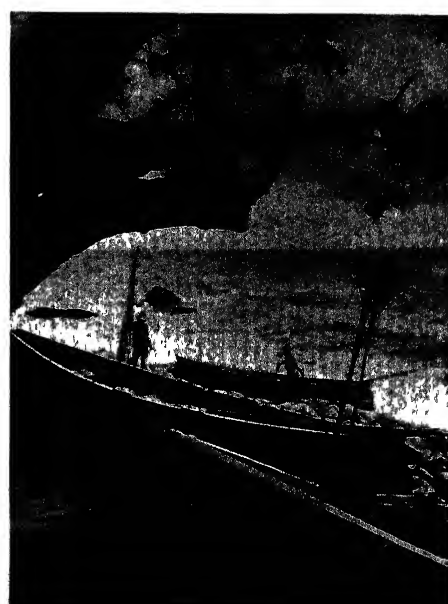
THIS SMALL TARN BELOW A MOUNTAIN SUMMIT PROBABLY OCCUPIES AN OLD VOLCANIC CRATER.

STEAM AND MIST ENSHROUD BOILING LAKE

THIS SEMIACTIVE CALDRON OCCUPIES LAND IN THE VALLEY OF DESOLATION, AN INACCESSIBLE BASIN OF ACTIVE VOLCANIC ACTION SITUATED IN THE SOUTHEAST PART OF DOMINICA ISLAND.

CLIFFS ON THE ATLANTIC COAST NEAR CALIBISHIE
THE RUGGED, PICTURESQUE WINDWARD COAST OF DOMINICA HAS A HEAVY SURF AND CONSTANT WIND.

Long a neutral island successively claimed by Caribs, England, France, and Spain, Dominica fell into the hands of the English as early as 1759. But it was too much for the French to have this threat strategically wedged between her important colonies of Martinique and Guadeloupe and, almost before the alliance between the revolting American colonies and France was announced, the French had seized the island by a swift surprise attack from Martinique upon Dominica's southernmost defenses. There, atop a hundred-foot-high narrow peninsula, now known as Scots Head, was located old Fort Cachacrou, which today, like all the old fortresses, is practically obliterated. The few soldiers on duty were cleverly duped into intoxication by ill-disposed French inhabitants; the touch-holes of the cannon were closed with sand so that when, on the morning of September 7, 1778, an attacking party under the Marquis de Bouille stormed the garrison, they were met with the opposition of only a handful of drunken wretches. A few days later a



CARIB CANOES AT SALYBIA
THESE ARE BUILT-UP DUGOUTS, CALLED *kuriala*, USED FOR ALL DEEP SEA FISHING. THEY ARE EQUIPPED WITH CRUDE SQUARE SAILS. NETS ATOP THE OARS ARE USED FOR SNARING FLYING-FISH.

A CARIB FAMILY NEAR SALYBIA IN THE CARIB RESERVE
MISCEGENATION IS RAPIDLY WIPING OUT THE FEW REMAINING NATIVE CARIBS OF THE ISLAND.

French force marched victoriously into Roseau, marking this as the first of a series of successes which were later to bring to the French king nearly all the smaller isles of the Caribbean. Matters were indeed critical, for the English in those days considered these islands far more important in potential wealth than the dissenting North American colonies! Little wonder then that Britain played all her cards in a final slam that saw the armada of De Grasse, newly arrived from victory off Yorktown, defeated by Rodney in one of the greatest naval engagements of all time. Off the north coast of Dominica, near the tiny group of islands called The Saintes, on April 12, 1782, the fleets of these two great naval powers clashed for a victory that decided once and for all which nation was to remain dominant in the West Indies. Since that memorable date French power has dwindled until today Martinique and Guadeloupe alone remain as Caribbean gravestones of what was once a mighty French-American empire. Thus ended one of a series of fights for which the island has long been famous—a warlike heritage handed down from the time of Carib ownership—when Dominica was not so named but was rather known to her savage children by their own and far more descriptive name of Waitubukuli, which means "Scene of Big Battles."

Not to be caught again unprepared, Britain started to construct fortifications on the northwest coast of Dominica to guard the one safe and beautiful roadstead the island can boast—near the tiny village of Portsmouth on spacious Prince Rupert Bay. On the neighboring Cabrits, twin peaks guarding the northern harbor shores, slave labor reared fortifications which boasted of being a second Gibraltar. Today few people even know of their presence. The cannon and great piles of century-rusted cannon balls are still in place, yet all is silent on the Cabrits. Wandering up their forested slopes one would little realize the military grandeur that once existed, so overgrown are the buildings; in fact, one needs a cutlass and a guide in order to find these extensive ruins. Soldiers are still present; they ramble off in their armor in hordes at one's feet—soldier

LOOKING NORTH FROM SYLVANIA HOUSE
LEFT, MORNE DIABLOTIN, HIGHEST PEAK IN THE LESSER ANTILLES; CENTER, MORNE COURONNE; RIGHT, TWIN-PEAKED MORNE GRAND BOIS. ORANGE ORCHARDS APPEAR IN RIGHT FOREGROUND.

crabs, the ghosts perhaps of human hosts of bygone days. And to the shaded parapets, long rent asunder by the roots of forest trees, now ascend only a stray chameleon or gecko. All is silent except for the constant cooing of doves or the sudden whir of wings as a *ramier* (wild pigeon) is startled from the treetops. One even needs to climb a tree to view the placid charm of the sweeping harbor below, sparingly dotted with tiny-oared fishing craft or perhaps a few inter-island sloops, far cries from the days when, it is said, sailing men-o'-war anchored here by the hundreds. Morne Diablotin, the Lesser Antilles' highest peak, slumbering in her perpetual cloud blanket, hovers dreamily over the island's past.

Dominica's longest road, narrow but paved, climbs out of the little village of Portsmouth over the eastern divide to the windward side of the island to Hatton Garden estate, about twenty-five miles distant, and then peters out in the forests lining the valley of the Pegoua River. Climb into a Dominica bus and ride, just for sheer fun, this roller coaster road to Marigot! A great Tarzan of a good-looking Negro will probably be driving, and on the long bare bench that is the driver's seat is usually a fair assortment of the island's good-natured peasantry, mostly laughing women with their gurgling babies. The bus, an old Reo, grunts and groans on the rises and comes to a squealing stop before thatched woodland doll-houses. People get on and off, passing babies from hand to hand to the front or rear of the bus into the arms of the waiting parent who has preceded them. Then comes the rain, only a passing shower but the bus has to stop, for as an air-conditioning aid the windshield was long ago removed. In no time at all the Atlantic appears ahead with her great wind-borne rollers chasing each other upon gorgeous tropical strands while picturesque Calibishie tries to seek refuge beneath her towering coconut palms. How cool and refreshing is this windward coast fanned as it is by a ceaseless breeze, which, combining its strength with that of the water, cuts queer pinnacles, stacks and sea cliffs out of the resisting shore. Even the low coastal vegetation is subdued by the

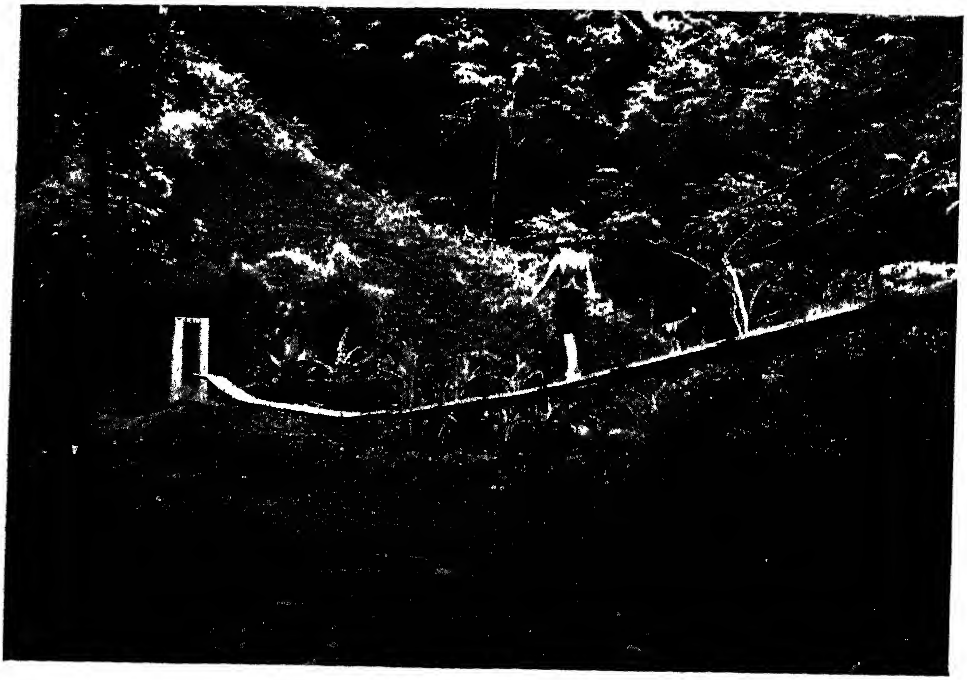
wind and appears brushed close against the mountainsides.

Villages south of Marigot on this windward coast can only be reached by rough canoe trip or by Carib trail. Following the latter on horseback over red, slippery volcanic soil, we slither atop sea cliffs or plunge into river-hewn gorges which periodically bisect the trail. Amid the wild beauty of this lonely coast there exist, scattered through the wooded slopes near Salybia and Bataka, the lone remnants of the Caribs, that old warlike race which Columbus on his second voyage of discovery found peopling the Lesser Antilles. In later days, even as against their ancient Arawak enemies, these Indians descended in hordes upon the incipient colonies on the neighboring islands of Barbuda, Montserrat and Antigua, and their ability to be swallowed up by Waitubukuli's impenetrable forests caused them to repel successfully all punitive expeditions sent against them. In his *History of the Caribby Islands* Davies relates that, "the Caribbeans have tasted of all the nations that frequented them, and affirm that the French are the most delicate and the Spanish are hardest of digestion." In 1640 a raid by them on Antigua resulted in the total pillage of that island, while another barbarous attack in 1666 culminated in the cruel murder of a former governor whose broiled head was carried back in triumph to their retreat on the island of great mountains and innumerable rivers. Only in 1796 was the Carib menace finally quelled.

We sought out a Carib boy to guide us through the island's mountainous backbone from Hatton Garden to Roseau. On this walk my opinion of Carib stamina was raised to a higher level, as that of my own reached an all-time low. I carried only a camera, but our Indian companion, weighted down with equipment considered sufficient to keep him properly tired, still kept up such a fast pace that we had repeatedly to ask him to slow down. Following the Hatton Garden River, now close to its boulder-chocked stream bed, now on a wooded cliff a hundred feet above, we gradually left behind the small cultivated valley floor. Five miles inland saw us up 1,500 feet and in deep mountain forest traversing a trail which sucked us deep into the muckiest of muds Now and then a distant roar would announce the swift approach of drenching rain—almost the only sound besides the squish-squash of the mud underfoot, or the whine of the guide's dog as he smelled out an agouti or *manicou* (opossum) in the sheltering buttresses at the base of some forest giant.

SYLVANIA: MOUNTAIN ESTATE
ORANGES GROWN ABUNDANTLY HERE ARE SHIPPED TO BERMUDA AND THE MARITIME PROVINCES.

Peak after peak was surmounted, and long after the sound of the highest rivulet draining to the Pegoua River had faded into silence, the sound of new rivulets ahead announced the passing of the height of land and the descent into the drainage system of Dominica's largest west-flowing, central stream—the Layou. Islanders boast of three hundred and sixty-five streams, one for each day in the year, and anyone who has traveled in the interior forests will certainly authenticate this number. These streams are the founts which nourish the clinging ferns, the pendant red and yellow heliconias of the gorge bottoms, the wealth of epiphytes, the gorgeous evergreen plumes of the soft bamboo. The incessant torrents are the artisans that have carved the island's rugged and precipitous landscape. The myriad



SWINGING BRIDGE OVER THE PEGOUA RIVER
THE LITTLE ISLAND BOASTS OF HAVING OVER 365 STREAMS, "ONE FOR EACH DAY IN THE YEAR."

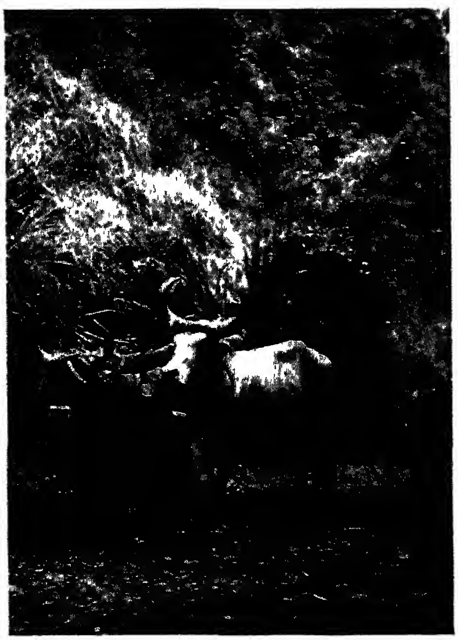
gorges and breathtaking waterfalls have created the chief obstacles to the encroaching civilizing attempts of man, and at the same time have supplied the inhabitants with fresh drinking water and streams free from breeding spots for malarial mosquitoes. The swirling waters at times eddy into pools which for bathing far surpass the tepid Caribbean.

Astride the central island mass, in the lee of the great peak they call Morne Trois Pitons, we stumbled upon an estate fittingly called Sylvania. Upon the mountain slopes, only recently forested, appeared a vision of carefully tended orange groves outlined against a yellow-green sea of delicately scented lemon grass. Ten thousand crates a year of "Tradewind" oranges find their way to Bermuda and Canada from this forest-bound estate, and indeed, in the tempering coolness of these mountain heights, the New-England-born owner has difficulty in keeping his fruit down to a marketable size!

Sylvania house has been justly called the show place of Dominica. From its thatched roof (to deaden the sound of driving rain on the galvanized iron beneath) to its jasmine-sweetened verandas it is every bit a story-book house set on a forest lawn. We spent many pleasant days at Sylvania, which is a dozen miles above Roseau via the newly surfaced Imperial Road—the corkscrew track which lifts one bodily from the Caribbean, jacks one above the khus-khus bordered lime orchards of the Canefield estate into a climate that is vigorous, new, and refreshing.

The rainy season was no time to be climbing mountains and especially not Trois Pitons. Lionel, the woodcutter, had emphasized that. He warned us that we would get bogged down in mud up to our knees, that it would be foggy enough to cut out all views, and cold besides. Despite our best arguments he could not seem to see the point that we had to climb when we could—now—and that we were after plants, not views; if he could have understood, he would still have thought us crazy. Since Sylvania stood nearly at 2,000 feet we were already in magnificent mountain rainforest which covers most of the land lying between 1,500 and 2,500 feet. (Below 1,500 feet is the low xerophytic tropical vegetation common to

many of the Antilles, while above 2,500 is the region of dwarf mossy-forest.) Unlike most temperate forests which are homogeneous, containing as they do but a small assortment of tree species, this tropical rainforest is heterogeneous, composed of innumerable species. In such a forest almost every tree seems to be different. All are evergreen hardwoods, the most prominent of which are known locally as *gommier* (*Dacryodes*), *chataignier* (*Sloanea*), *carapite* (*Amanoa*), *bois côte* (*Tapura*), and *bois diable* (*Licania*). Boles ten feet in diameter are common, and many of the trunks of these giants are thrust two hundred feet into the air from bases that flare like the flying buttresses of continental cathedrals. Arboreal foliage is so high above one's head as to defy recognition, but from this canopy drop the cord-like roots of *kaklin* (*Clusia*), a common strangling arborescent epiphyte. On the trees appear numerous vines, such as marcgravias, *zelle mouche* (*Carludovica*), which lift their festooning cables to the sunlight, while lower down are aroids and ferns clutching at every foothold. Beneath the trees the light is dim and ground vegetation is never dense. A rubiaceous shrub (*Cephaelis*), with tiny white flowers surrounded by waxy blue-bracts, is most common living among colonies of low ferns, feathery selaginellas, or occasionally with various rare terrestrial orchids. But colorful plants are few and over all is just the leaf green of the forest.

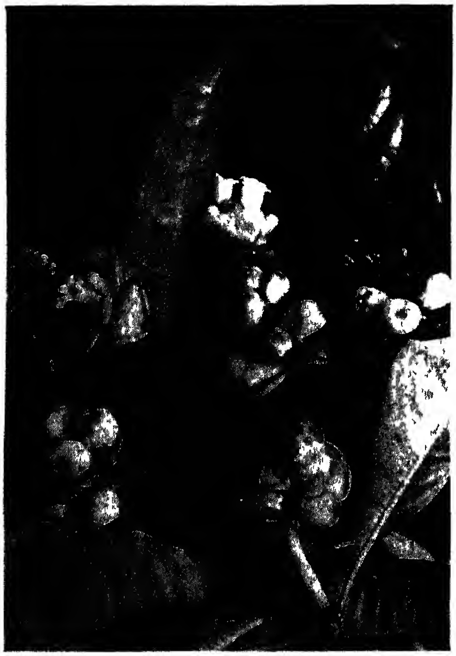


FRAGRANT LEMON GRASS
GROWN IN LIME ORCHARDS FOR GREEN MANURE.

A VIEW IN THE MOSSY FOREST
THE MOUNTAIN FOREST'S IMPENETRABLE GROWTH IS COVERED WITH MANY TYPES OF EPIPHYTES.

Following a woodcutter's trail we found ourselves in the twilight of this solemn cathedral setting where the choristers were the various thrushes and the mountain whistler (*sifleur montagne*): a solitaire whose clear flute-like notes, combined with the gurgling cadenzas of a Dominican wren, offered fitting accompaniment to the unusually quiet green pageantry spread around us. Here also is the home of two rare parrots—"Jacquot," or *cicerou*, and the Imperial (largest of its kind in the world)—which commonly flush from the *bois diable* or *pipiri* trees on whose fruits they are accustomed to gorge. Besides this game, woodsmen hunt pigeons (*ramier, tourterelle,* or *perdrix*) as well as wild pig, agouti, or opossum (*manicou*).

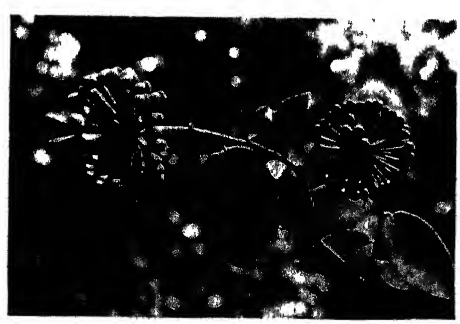
One has to become an acrobat on the uppermost grueling slopes of Dominica's mountains, for here the constant trade-wind causes the forest aspect to change. The trees are of



CEPHAELIS SWARTZII
THE FOREST'S COMMON UNDERSHRUB HAS WHITE FLOWERS SURROUNDED BY WAXY BLUE-BRACTS.

different species and are dwarfed, twisted, and massed in impenetrable and grotesque fashion upon the steeply pitching slopes in such a way that one can only make progress by clambering hand over hand through the appressed, dripping, wind-blown treetops Rain here, except on rare occasions, is almost incessant, with the result that mosses are everywhere, covering the limbs like cushions and spilling out water at every touch; their presence in such numbers gives to this upper region the name mossy-forest. Great bromeliads are astride every tree, while delicate threads link the dainty fronds of the many elfin filmy ferns. Only in very restricted areas is this low forest absent, and here the rocks are covered with bromeliads, mosses, creeping lycopodiums and a beautiful purple-flowered dwarf shrub (*Tibouchina*). We soon learned why Lionel had so quailed at coming. He sat, while we collected at the summit, a shivering example of dejection. To us it was not cold, perhaps sixty to sixty-five degrees, and yet on that misty, cloud-shrouded summit he was probably experiencing the coldest weather of his island life! To gain the actual summit of most of Dominica's peaks one has carefully to follow the course of some steep ridge that in many cases is so sheer as to form a knife edge which almost can be straddled. On another occasion we revisited Trois Pitons' summit and were blessed with a miracle in weather—full sunlight on a peak whose summit contours were practically unknown Such weather permitted the taking of the first photographs which really show the summit configurations of Dominica's little known and inaccessible peaks. Visitors to Dominica's interior have been few, with the result that it is a paradise to the plant collector, and indeed the best "pickings" on the island were from Trois Pitons' upper slopes. Here were discovered, besides other rarities, a fern, three shrubs, and two palms—all new to science

It was easy to descend the steep slopes, for with mud-oiled pants it was a quick downward slide on slippery clay! Back at Sylvania the sun had already slid behind the slopes to the west and an insect chorus was ushering in the night At no other time are Dominica's forests more lovely; from the sheaths of the palm leaves comes the "crack-crack" of the huge katydids; high up in the plumose bamboo the blacksmith beetle sends down clear notes like the sound of a hammer on a tiny anvil; while on every side are the myriads of tiny lanterns of the island's astounding fireflies. These woodland fairies, the "labelles" of the natives, are tropical giants among lightning bugs, and when "afire" look like tiny automobiles moving in the darkness with two headlights and a tail-light behind. The lights of just one of these creatures are bright enough to enable a person to read, and in the days when the island



MARCGRAVIA
COMMON DECORATIVE VINE OF THE WET FORESTS.

A WEST INDIAN BULLFINCH
CAUGHT DRINKING FROM A *Heliconia* BRACT.

was known as Waitubukuli the Carib owners employed these woodland gnomes for many a useful purpose, attaching them to their feet and hands when traveling after dark; using them instead of flambeaux on hunting and fishing expeditions. Furthermore, the mashed bodies of labelles possess for a short while the qualities of a phosphorescent paint, and Indian war parties are said to have supplanted the red anatto warpaint of daylight with firefly phosphorescence, thus terrifying their enemies with "flaming countenances."

After such a day's revel in the mountains, when tropical night silences all but insects and thoughts, it is easy to agree with William Palgrave, the great writer and traveler, who wrote, after visiting Dominica in 1876:

> In the wild grandeur of its towering mountains, some of which rise to five thousand feet above the level of the sea; in the majesty of its almost impenetrable forests; in the gorgeousness of its vegetation; the abruptness of its precipices, the calm of its lakes, the violence of its torrents, the sublimity of its waterfalls, it stands without a rival, not in the West Indies only, but, I should think, throughout the whole island catalogue of the Atlantic and Pacific combined.

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## THE MOUNTAIN WHISTLER OF DOMINICA

It is while carefully balancing myself on my shaking support of matted roots, that a sound comes to my ear through the roar of a waterfall—a sound strangely sweet, solemn, and impressive; a mellow, organ-like note, clearer than any flute-tone, more thrilling than the solemn chant of sacred song in groined cathedral. It is repeated. I stand entranced, listening to melody that had never fallen on my ears before. The cause I cannot at first ascertain, for the notes seem ventriloquial; and indeed they are so, for I search high and low, the leafy branches above my head, the densely clustered ferns at my feet, and the shrubs at my back, for many minutes, before I find the source of this mysterious music. Balanced airily on a lance-like bamboo that shot twenty feet beyond the brink of the cliff, poised in mid-air, with half a thousand feet of space between him and solid earth, is a daintily-shaped bird, clad in sober drab, save a dash of rouge beneath his throat, and of white here and there.

Unconscious of surrounding things, animate and inanimate, he was devoting his powers to the production of that wonderful music. . . . Surely no flute ever produced such mellow, liquid tones. It was music of unearthly sweetness, that, once heard, would never be forgotten—between the notes a long pause, that made them most impressive. It was not a song—though I discovered later that the little bird had a song—but simply the utterance of a few notes. Soon it ceased, and the bird flew into the near forest, where I soon discovered it busily feeding upon the berries of a tall shrub, to the pendant branches at which it was clinging, now and then dashing at a fugitive bunch, apparently as absorbed in this occupation as in his melodious lay of a few minutes before. Soon he ceased feeding, and commenced preening himself upon a naked limb; then, after smoothing himself out, as it were, and drawing in and stretching out his neck, he suddenly dashed at a single berry, swallowed it to clear his throat, and recommenced to trill. He had uttered but a few notes when he silently flew to a dead branch; a few more and he winged his way to a swinging "liane," where he hung suspended above a little ravine, in which is sunk a tiny stream, whose tinkling waters made music, though not so sweet and liquid as his. Then he disappeared in the dark recesses of the forest, where it would be useless to follow him, but whence came at intervals the ventriloquial music that seemed to float over my head and around me, though the bird was afar.

This bird is called by my mountaineer friends, who have a name, and an applicable one, for everything in the forest, the "*Siffleur Montagne*," or "Mountain Whistler."

—From *Camps in the Caribbees: The Adventures of a Naturalist in the Lesser Antilles*, by Frederick A. Ober, Boston, Lee and Shepard, 1880, pp. 19–20.

# ENGINEERING IN MEDICINE*

By ALVAN L. BARACH

In discussing applications of physical principles to clinical medicine and, for the sake of illustration, to aviation medicine also, I shall stick to the narrow bridge which I have crossed between these principles and the treatment of respiratory illness. Needless to say there are other more remarkable examples of the relations between physics and medicine, but I feel less likely to fall into the abyss of fanciful conjecture if I stay for the most part within the boundary of my own experience.

## I

Two decades ago the physiological basis for administering oxygen to patients with respiratory illness was being placed on a solid foundation, but comfortable and effective methods of providing oxygen-enriched air, containing two or three times the normal percentage of oxygen, were yet to be developed. A funnel held in front of the face was then the most common appliance, but it was almost worthless and generally used as a gesture of last resort. The mask of Haldane and rubber tubes inserted into the nose were more effective, but any appliance fastened to the face was found objectionable by many patients. The clinical value of oxygen therapy could not be established by using methods that were ineffective in overcoming the lack of oxygen from which the patient suffered, or that were uncomfortable or objectionable in application.

An oxygen tent designed by Leonard Hill consisted simply of a canopy over the patient, but since it did not provide for eliminating heat and moisture it produced a warm and humid atmosphere. Our early attempts, with Binger and Roth, to remedy this situation by passing air through copper pipes packed in ice for cooling, and through soda-lime and calcium chloride containers for removing water vapor, failed to provide a hygienic atmosphere in respect to temperature, humidity, and air movement. The idea of blowing an oxygen-enriched atmosphere directly over chunks of ice contained in a refrigerating cabinet seemed to possess theoretical advantages because a wide surface area of a cooling medium was obtained with minimal resistance to the circulation of air. In the first actual trial after the copper pipes were removed and pieces of ice were inserted in the same container, the effect on the patient was remarkable and almost instantaneous. With the increased comfort provided by cool, dry air he relaxed and fell asleep—the beneficial effects of oxygen therapy were no longer obscured by factors which interfered with his well-being in other ways Further improvements in accessories were necessary, such as transparent canopies (Fig. 1) and noiseless motors, but the main objective had been achieved in an obviously simple way. The temperature of the air dropped 15° F. and the relative humidity 25 percent. The oxygen tent from that time on was capable of offering the patient not only an atmosphere of forty to sixty percent oxygen, but also one that was hygienic in respect to temperature, humidity, and air movement.

Oxygen rooms had previously been constructed by Barcroft and Stadie which were ventilated by motor-fan units and which were sufficiently leak-tight to permit the maintenance of an oxygen concentration above fifty percent. Rigid care had to be taken to prevent sparks in an atmosphere in which a high percentage of oxygen was present. Partly to avoid this danger, a simpler method of ventilating a room was developed in which no electrical contrivance was necessary. When series of one-inch pipes were installed across one side of a room with either ice water or brine circulating through them and a steam radiator was placed on the other side of the room, thermal circulation, cooling,

* From the Department of Medicine, College of Physicians and Surgeons, Columbia University, and the Presbyterian Hospital, New York; sponsored by the Committee to Study Air Conditioning, American Medical Association, Carey P. McCord, Chairman, Alvan L. Barach, Commander W. M. Simpson, and C. P. Yaglou. The illustrations for this article are from a forthcoming book, *Principles and Practices of Inhalational Therapy* (J. B. Lippincott), by the author.

and dehumidification of air were satisfactorily obtained. This type of ventilation had the advantage of being noiseless and usable in any room that could be made leak-tight. Oxygen rooms of this type (Fig. 2) have been in use since 1925, at first in the old Presbyterian Hospital, New York City, and now at the Columbia-Presbyterian Medical Center, without any fire or other untoward difficulty.

Transportable oxygen rooms (Fig. 3) have been installed in private homes in which patients have lived for the greater part of both day and night for months and even for years. Although cure of chronic pulmonary disease is not effected by oxygen treatment, betterment of respiratory function, relief from labored breathing (dyspnea), increased comfort, and prolongation of life may be accomplished.

Helium was later introduced as a therapeutic gas partly because it is chemically inert and does not form an explosive mixture with oxygen, but principally because it is lighter than any other element except hydrogen. A mixture of eighty percent helium and twenty percent oxygen has a density of only one-third that of air or oxygen. Since the velocity of gas movement by effusion or diffusion through a constricted orifice is inversely proportional to the square root of the molecular weight of the gas, it follows that such a lighter-than-air mixture can be breathed in conditions of obstructive dyspnea with about one-half the effort required for the inhalation of either air or pure oxygen.

FIG. 1. TRANSPARENT TENT FOR THERAPY WITH CONDITIONED OXYGEN

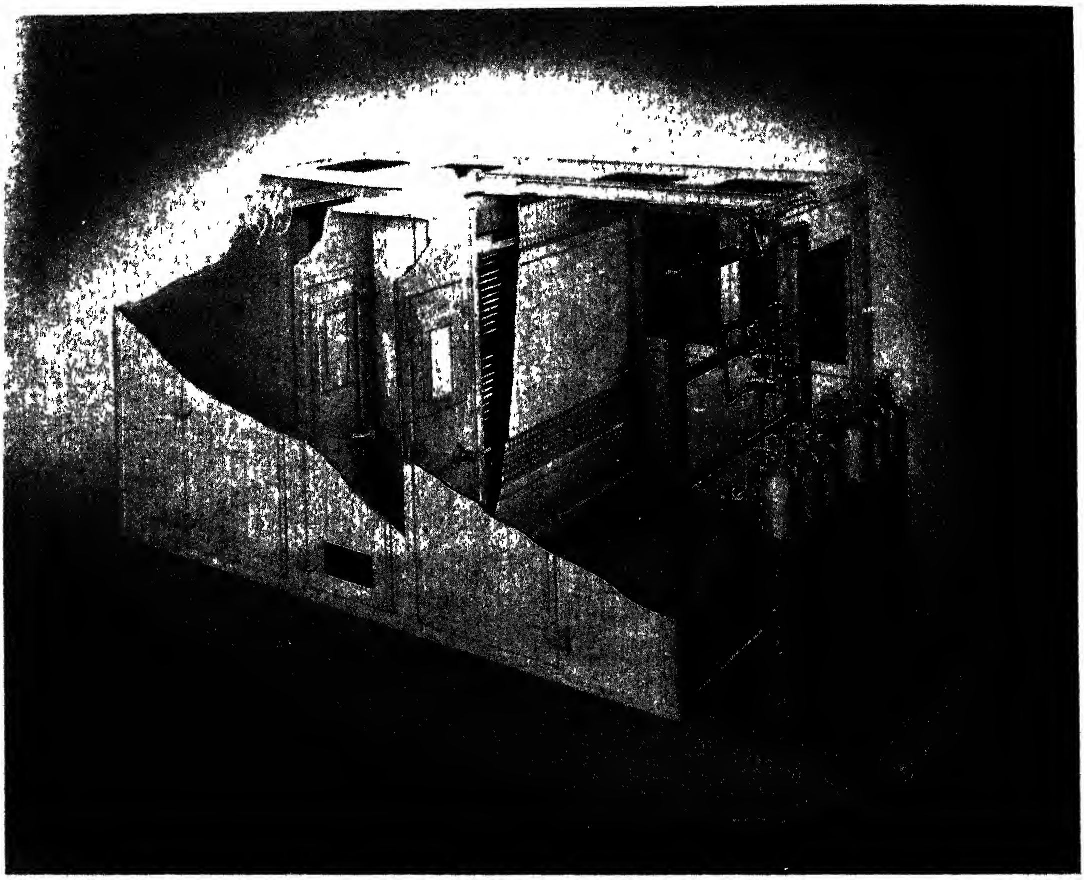


FIG. 2. OXYGEN CHAMBER VENTILATED BY THERMAL CIRCULATION

The inhalation of helium-oxygen mixtures by patients with severe asthma has in many instances been a life-saving measure; as a result of repeated inhalations of helium with oxygen in intractable asthma, bronchial relaxation may take place and, in a number of cases of this type, a state of relatively mild or no asthma has been initiated. This inhalational treatment of asthma is not a cure of the disease, but it is a remedy of such value that it may relieve intractable asthma for periods of six months and sometimes for more than a year.

In conditions of localized obstruction in the upper respiratory passageway a helium-oxygen mixture has also been employed in order to decrease the effort of breathing and to increase the velocity of gas movement. In the use of helium-oxygen mixtures the oxygen tent has not been found effective, since this gas readily leaks through the points of contact which the tent makes with the bed. Although this gas can be used with a mask, a helium-oxygen helmet hood (Fig. 4) was developed which enclosed the head of the patient, making contact at the neck. When a positive pressure of two to five centimeters of water was maintained within the hood it was soon found that breathing became remarkably more comfortable. Very severe cases of obstructive dyspnea, both asthma and lesions in the larynx and trachea, have been controlled in this way.

## II

The stimulus which led to the use of positive pressure in bronchial asthma originated from an observation that one of our first patients who was treated by helium-oxygen therapy habitually breathed in such a way as to create an obstruction at his mouth during expiration. With his lips partially

closed, he would slowly blow out against an arbitrarily imposed and very obviously narrowed orifice. When I suggested that he was making his breathing harder and that he should open his mouth to breathe, he lapsed into a state of uncontrollable asthmatic dyspnea, indicating that his manner of breathing had some functionable significance.

When, in cooperation with Swenson, lipiodol was inserted into the lungs of a patient with bronchial asthma, the X-ray showed that, if the patient was exhaling under a positive pressure, the bronchial tubes did not constrict so much as they did in ordinary unobstructed expiration. With that hint in mind, patients with helium and oxygen in the hood were exposed to a continuous positive pressure in the helmet of three to six centimeters of water. This small degree of positive pressure during expiration was reflected back into the respiratory passageway and prevented the bronchi from collapsing with the result that the decrease in the total volume of lungs during the expiratory cycle was diminished. Of even greater importance was its effect on the inspiratory cycle, since the presence of an additional positive pressure at the entrance of the lung was capable of blowing the atmosphere into the lungs instead of making it necessary for the patient to suck it in through a constricted orifice.

It has been shown by experiments on animals that a high negative pressure develops within the lungs when breathing takes place through a narrowed orifice. When the air is forced into the lung from the outside this pathologically elevated negative pressure, which is produced by forcible contraction of the diaphragm and chest muscles, is much reduced. The disadvantage of the patient's employing a high negative pressure in the chest to suck in air past a constricted orifice is that it exerts a cupping action on the pulmonary capillaries and on the mucous membrane of the bronchi, tending to cause exudation of mucus and serum. In some instances

FIG. 3. PORTABLE OXYGEN CHAMBER FOR USE IN HOMES

such a pulmonary edema takes place in human beings as a result of long-continued respiratory obstruction. Edema of the lungs was consistently produced in animals by having them inspire through a constricted orifice, or against a negative pressure of six centimeters of water.

As long ago as 1878 Oertel employed one hundred inspirations under positive pressure in the treatment of asthma, and Haven Emerson, in 1909, showed by experiments on rabbits that artificial respiration conducted under pressure prevented or cleared edema of the lungs due to previous injection of adrenalin. Other observers, such as Auer, Loeb, and Gates, confirmed these observations. However, little or no clinical application had been made of them, except with the apparatus of Plesch used by Poulton.

The helium-oxygen hood offered a comfortable and effective way of providing positive pressure in conjunction with gas therapy. A number of cases in which there was a marked outpouring of serous fluid from the capillaries of the lung into the air spaces were treated by positive pressure with a resulting swift clearing of the edema in a number of instances. In some cases there was a prompt recovery from what otherwise would have been regarded as a fatal illness. A mask for the application of positive pressure during inspiration and expiration is shown in Figure 5.

A result of pressure applied to the outside of the capillaries in the lungs is to counteract directly the internal hydrostatic pressure in the blood vessels. This opposing exterior pressure retards the tendency of the capillaries to ooze when there is either an increased pressure within them, as in heart failure, or some change in permeability of the capillaries, as in pneumonia or gas poisoning. Another effect of positive pressure within the chest may be to retard the inflow of blood into the right heart. In cases of cardiac failure such a pressure allows the heart to work with a diminished volume of blood. In normal individuals the increase in venous pressure largely compensates for the retarding effect of the increased physical pressure in the lung, as is proved by the fact that the circulation time was found generally maintained near its normal level.

More recently an apparatus has been developed in which positive pressure in expiration alone has been provided. In collaboration with Eckman and Molomut, I have used a mask apparatus in which expiration proceeds through a tube immersed in a water bottle or through a flutter valve surrounded by a metal disc that is punctured with orifices of various sizes. In the largest orifice there is no resistance to expiration, but as the disc is moved to smaller and smaller orifices the resistance to expiration becomes greater and greater. This mask (Fig. 6), employing positive pressure in expiration, has been used in the treatment of clinical pulmonary edema, and also by Carlisle in the edema of gas poisoning from fumes of chlorine or nitric acid.

The foregoing experience points to the possibility that breathing against a positive pressure may aid in overcoming the consequences of pulmonary irritant war gases. In the absence of oxygen a mask of this kind may be used to advantage simply by removing the collecting bag and inspiring air through the inspiratory valve, and exhaling it through the expiratory valve and the selected narrowed orifice. In the absence of a mask, expiration through a cigarette holder can be used and has, in fact, been reported as an emergency measure in the clearing of pulmonary edema in two clinical patients.

It appears, therefore, that there is a functional significance in grunting and groaning by patients with respiratory illness, although these symptoms are ordinarily thought of as subjective complaints. A characteristic symptom of lobar pneumonia is an expiratory grunt, in which the patient at the beginning of expiration holds his breath, closes his glottis, develops an increase in intrapulmonary pressure, and then gradually exhales in a grunting or groaning form of breathing. I have a memory of many years ago when I had a patient, ill with lobar pneumonia, who grunted and was suffering considerably. I gave this patient two doses of morphine which stopped the expiratory grunt but he lapsed into edema of the lungs.

My conclusion is that the expiratory grunt is a beneficial action, and that consequently it is justifiable to speak of the physiological


FIG. 4. HOOD FOR ADMINISTRATION OF MIXTURES OF HELIUM AND OXYGEN

advantages of grunting and groaning. Where patients who have had a long-standing obstruction of the larynx are suddenly relieved by making an incision into the windpipe, they will often develop exudation of serum and mucus from the pulmonary capillaries and from the bronchi. This exudation can be controlled by having these patients inspire normally and expire under positive pressure, as shown by Woodman and later by Kernan and me.

In the mask apparatus mentioned above, variable concentrations of oxygen can be obtained by the use of an injector attached to the regulator. As oxygen passes through it in a swift stream, a negative pressure is developed within the metal injector which draws in a variable amount of outside air, depending upon the size of the orifice open to the atmosphere. Calibration of these orifices in experiments made possible the instantaneous provision of oxygen concentrations between forty and one hundred percent with an error not exceeding three percent.

## III

I now pass to the consideration of a method for immobilizing the lungs that is also based on an application of engineering principles. In 1926 Thuneberg showed that an apparently adequate pulmonary ventilation could be maintained in case of respiratory paralysis by placing the patient in a chamber in which an alternating pressure of one-sixth of an atmosphere above and below normal was used. Drinker and his collaborators then developed the respirator, now commonly known as the "iron lung," in which the body of the patient is enclosed in a box with the head protruding outside. When a motor blower unit or bellows creates a suction pressure of fifteen centimeters of water within

the chamber, the chest is expanded during inspiration; when this is turned off, the chest returns to the expiratory position as the result of atmospheric pressure.

My interest in immobilizing the lung was to secure lung rest in patients having pulmonary tuberculosis. An air-tight room was first constructed in which patients could be subjected twenty-five times a minute to alternating pressures of fifty-five millimeters of mercury above and below that of the atmosphere This change was sufficient to force air in and out of the lungs, but it was soon evident that during the positive phase the air pressure compressed the chest slightly, and that during the negative pressure phase the chest was momentarily expanded. This movement of the chest was traced to the resistance of the tracheo-bronchial tree to the free flow of air, which delayed and decreased the application of pressure to the inner surface of the lung.

An air-tight box was then constructed around the body of the patient, with the head protruding into the original chamber. When small apertures were made in this box, it was possible to retard the application of pressure to the chest to keep pace with the pressure of air in the lungs that had entered through the nose and mouth. In that way we were able to equalize the pressure on both the inner and outer surfaces of the chest wall, and on the diaphragm as well, so that little or no discernible movement of them took place either on ordinary observation or on X-ray examination of the margins of the diaphragm. An adequate movement of gas molecules in and out of the immobilized lung provided a plentiful supply of oxygen and eliminated the carbon dioxide

After the method of immobilizing the lung had been perfected, a number of persons having advanced pulmonary tuberculosis were given the lung rest treatment. In six of eight cases there was a clearing of the lesions due to tuberculosis and most of these patients are now living or working without any evidence of active infection. Although this method (Fig. 7) of immobilizing the lung is a practical procedure which is comfortable to the patient and has been effective in some instances in promoting a cure of advanced

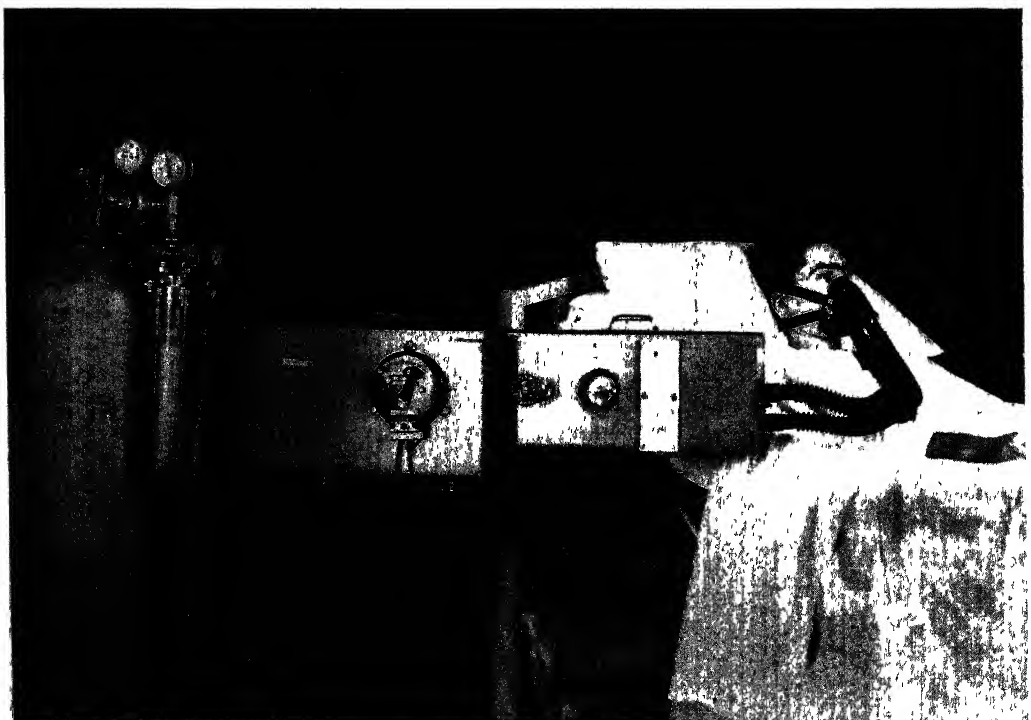


FIG. 5. ADMINISTRATION OF OXYGEN UNDER CONTINUOUS POSITIVE PRESSURE

pulmonary tuberculosis, after other measures had failed, more studies are necessary in order to determine the range of its usefulness.

## IV

It will be instructive to consider an illustration of the ease with which physical principles may be overlooked in medical problems, particularly by those whose training is in medicine and not engineering. Such a problem of great importance is now before medical men and engineers.

In dealing with the physiological factors involved in high altitude flying, we are faced first of all with the fundamental fact that a unit of gas at constant temperature expands in proportion to the decrease in pressure to which it is subject. For example, a liter of gas at sea level will expand in the free state to six liters at an altitude of 42,000 feet. Since the volume of the chest is constant, it is evident that even though pure oxygen is inhaled the molecules are so widely separated at very high altitudes as to be unable to provide a normal oxygen pressure in the lungs and, therefore, in the blood and the tissues. One of the interesting characteristics of the human mechanism found under these conditions was that the expansion of gases obscured certain physiological happenings within the body.

TABLE 1

PERCENTAGE BY VOLUME OF OXYGEN, CARBON DIOXIDE, AND WATER VAPOR IN THE LUNGS, AT SEA LEVEL (760 MM. HG) AND AT 42,000 FEET (128 MM. HG), WHEN BREATHING 100 PERCENT OXYGEN

| Gas | Sea level | Altitude 42,000 feet |
|---|---|---|
| Oxygen | 88.5 | 35.2 |
| Carbon dioxide | 5.3 | 28.1 |
| Water vapor | 6.2 | 36.7 |

At sea level the atmosphere has a normal pressure of about 760 millimeters of mercury and at an altitude of 42,000 feet a pressure of about 128 millimeters of mercury. Consequently if ordinary air is breathed at such a great altitude, or in a decompression chamber having corresponding conditions, not enough oxygen will be available in the lungs to sustain life. Since only about twenty per-

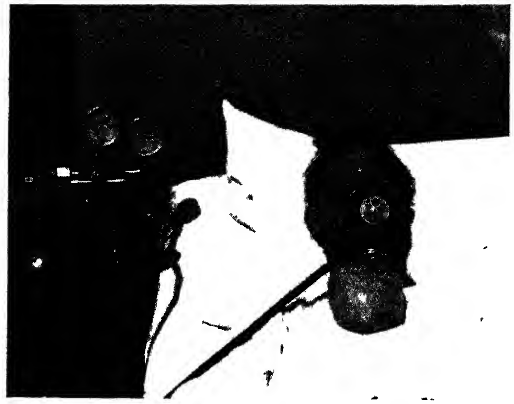


FIG. 6. OXYGEN METER MASK
CONTROLLING POSITIVE PRESSURE DURING EXPIRATION.

cent of the atmosphere is oxygen, it is natural to assume that its deficiency in the lungs at high altitudes, even up to 42,000 feet where the atmospheric density is only one-sixth that at the surface, can be largely restored by breathing pure oxygen. This would be the case if it were not for certain other interesting and important physical aspects of the problem which experiments forced us to consider.

The tube through which aviators breathe oxygen from containers at high altitudes must not be gas tight at both ends, for otherwise the pressure on the interior of the lungs might become much greater than the atmospheric pressure on the outside with disastrous results. Consequently at every altitude aviators must breathe gases having the same density as the surrounding atmosphere. There could be an exception only if they should be enclosed in air-tight cabins in which the pressure could be kept above that of the exterior air.

When an aviator inhales pure oxygen his lungs are filled partly with oxygen, and partly with water vapor and carbon dioxide released into them through the capillaries of the circulatory system. There is such an abundance of water in the blood that the lungs are always saturated with water vapor. The amount of water vapor for saturation depends upon the temperature but, contrary to what might be expected, is independent of the amount of other gases present. Therefore, since the temperature of the lungs is the same whatever the altitude, the amount

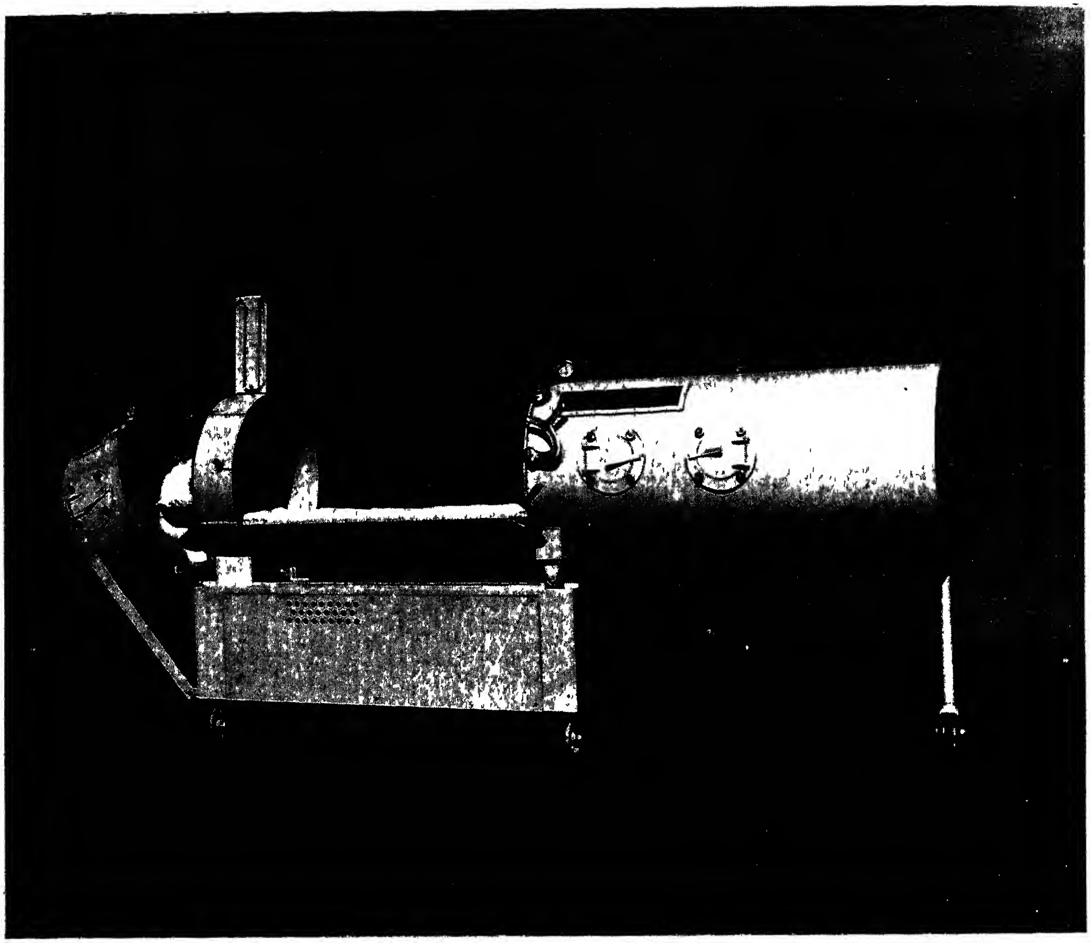


FIG. 7. EQUALIZING PRESSURE CHAMBER FOR IMMOBILIZATION OF THE LUNG

of water vapor in them at high altitudes is the same as at the earth's surface. Since the oxygen in the lungs decreases with altitude whereas the water vapor remains constant, the relative percentage of water vapor increases. At sea level water vapor constitutes about six percent of the contents of the lungs; at an altitude of 42,000 feet this percentage rises to about thirty-six (Table 1).

Conditions are similar with respect to carbon dioxide. At sea level the percentage of carbon dioxide in the lungs is a little over five, whereas at a pressure corresponding to an altitude of 42,000 feet it is twenty-eight.

With the results at hand for both water vapor and carbon dioxide in the lungs, we can calculate the relative oxygen content of the lungs of an aviator breathing air at sea level and pure oxygen at an altitude of 42,000 feet. On taking these factors into account, it is found that an aviator gets considerably more oxygen when breathing air at sea level than he does when breathing pure oxygen at an altitude of 42,000 feet, or in a decompression chamber with an atmospheric density the same as that in the open air at an altitude of 42,000 feet. This result indicates that in order to ascend to great altitudes the personnel will have to be enclosed in airtight cabins in which atmospheric pressures can be maintained above that of the exterior air.

In the course of our determinations of "vital capacity" at different altitudes, a phenomenon was met that was puzzling until the explanation occurred to my colleague, Mr. Eckman. Vital capacity is the maximum volume of air a person can expel from his

lungs after inhaling deeply. This maximum capacity of a person is measured by his first taking the fullest possible inspiration and then exhaling it as completely as possible into a spirometer, which measures the amount of air admitted into it. Evidently the lung capacity of a person is the same at all altitudes. But when the vital capacity of a man was found to be. 5,000 cubic centimeters at sea level, a test would show it to be about 4,000 cubic centimeters at a pressure corresponding to an altitude of 42,000 feet. Mr. Eckman noted that the exhalation was from the lungs at temperature of 99° F. into a spirometer at a temperature of 68° F. Since in the lungs the vapor pressure of the water would always be the maximum possible for the temperature, condensation would follow the exhalation into the cooler spirometer. As is shown in Table 1, at sea level only six percent of the air in the lungs is water vapor, while it is thirty-six percent at an altitude of 42,000 feet. Therefore the water condensed at the higher altitude would be a much larger fraction of the contents of the lungs than at sea level. An experiment in which the subject breathed into a spirometer at 99° F. gave the same value for the vital capacity at both altitudes and verified the theory.

There are many other examples of applications of physical principles in clinical and aviation medicine, but those that have been presented from actual experience are sufficient to illustrate the importance of broadening the base for medical education. Heretofore students have generally entered medicine through the avenues of biology and chemistry, whereas those taking physics have preferred engineering. Wider horizons are needed.

*Beware of the generalist who is not a specialist but beware of the specialist who is not a generalist.*—Blake.

# RACE AND PUBLIC POLICY

By LOUIS WIRTH

ACADEMIC men are inclined to ascribe an importance to knowledge all out of proportion to its actual role in human conduct. This is particularly true of race relations. Men do not wait until the latest findings of science are in before they begin to feel, think, or act on matters that concern race; and even when new scientific findings come to hand it does not follow by any means that people will promptly change their beliefs and actions to conform to them.

*Race and Reason.* This is not to argue the futility of the search for tenable knowledge about race and race relations, but merely to indicate the limits of its effect upon practice. In the beginning was the act, not the thought. Frequently, however, men cling tenaciously to a belief even in the face of overwhelming evidence of its falsity. They often persist in a type of conduct which is flagrantly contradicted by both the factual premises upon which it supposedly rests and its practical outcome. And yet, if we are pursuing the quest for knowledge for any other reasons than its own sake, we must assume that ultimately, if not always, knowledge does make a difference. Many illustrious examples from history support this assumption.

Although the displacement of superstition and dogma by science, even in the fields of technology and medicine, to take but two instances, has by no means been as rapid and as automatic as might be wished, in social affairs, in matters that affect religion, the family, nationalism, and race, scientific findings have made their way into belief and action even more slowly. This appears to be due not merely to the supposed fact that scientific findings in these latter fields are less certain and more personal, but rather to the circumstance that established beliefs and practices in these matters have an almost sacred character and are not subject to secular, objective scrutiny. In matters of race even a Hitler or a Goebbels may pose as an expert and be accepted as such by millions, whereas probably no one would accept them as experts in medicine or engineering. We must assume, nevertheless, that the search for truth by the methods of science is at least as important in the realm of the social as it is in the realm of the physical and biological and that ultimately here, too, the truth shall make men free.

*The Nature of Race Prejudice.* What we know and what we do not know about race would be merely a prosaic academic matter if it were not in the minds and actions of men associated with some of the most acute practical problems of human relations in our day. These problems range from personal idiosyncrasies and antipathies to violent mass conflict and the clash of national and international policies. It is the latter type of problem that constitutes the subject of this paper. But before treating the subject of race and public policy, a word needs to be said about race relations as personal relations.

All of us have our likes and dislikes, our preferences and antipathies. We prefer certain foods over others; we have our personal tastes in clothing and furniture; we ride hobbies and have our blind spots in art and in recreation; we have our passionate affections and our equally deep-seated revulsions toward other persons. All of these, however, are matters of little if any public concern. We regard them as private affairs.

Our tastes, our preferences, and our antipathies, however, are not altogether of our own making and the result of our own personal experiences. For the most part our personal pattern of race relations is made for us by the culture in which we live, just as our behavior patterns in other respects bear the imprint of the group to which we belong. We have preconceived attitudes toward objects and persons that we have never met. These attitudes tend to be more verbal than actual. It is difficult for us to work up very much enthusiasm for, or antagonism against, people whom we have never seen, although we may have stereotyped notions about how we are to react to

the symbols representing these unfamiliar persons. In a race-relations survey made some years ago on the Pacific Coast, a considerable proportion of native-white Americans who were questioned exhibited a markedly distant and unfriendly attitude toward Turks, although probably few, if any, of those who held this attitude would recognize a Turk if they met one. Strange as it may seem, the genesis of this attitude may be in part the inadvertent by-product of the Sunday school experience which many American youths underwent when they dropped their pennies in the collection box to save the persecuted Armenians from the "Terrible Turk."

Prejudices are judgments that we pass on objects or persons before we have had any experience which would give us reasonable grounds for feeling or acting as we do. These "pre-judgments" are the result of our predisposition to lump objects or persons together into classes or categories irrespective of their individual differences or merits. When we treat one person cordially and as an equal, and another in a hostile fashion or as an inferior because the former belongs to our race and the latter to a different race, we are exhibiting a racial prejudice. Whenever we hear people say, "I don't like Americans, Englishmen, Russians, Negroes, Jews, Catholics because they do so and so," we may be sure that what follows the "because" is an attempt to justify on rational grounds an attitude which rests upon emotional bias. No people as large as any of the groups mentioned above are so much alike that the same judgment could conceivably apply to all of them. Our pre-judgments of other people, especially of racial and ethnic groups, are not rationally examined in the light of our own experiences with a substantial number of members of such groups. They are for the most part imbibed by us from the popular beliefs held in our own group, sometimes transmitted unconsciously by our elders and our neighbors through example, sometimes the product of education and not infrequently of deliberate propaganda. The fact that there is no rational or experiential justification for these beliefs, however, does not make them any the less potent.

To most white people all Negroes look alike. Most Americans, even now, find it difficult to tell the difference between Japanese and Chinese, between Koreans, Filipinos, and Puerto Ricans. Only when we get to know certain members of these groups intimately do we begin to distinguish between individuals and to note that there is as much difference between different persons in each of these groups as there is between persons in our own group. Just as we ascribe identical physical traits to them, so we are inclined to ascribe identical mental, social, and moral traits to people whom we know only by their racial labels. Thus, for instance, we attribute a racial odor to Negroes because we have met one or a few individuals whose smell offended us. We forget that perhaps white individuals working in the same occupations or living under comparable conditions might have an equally offensive odor. We meet a member of another racial or ethnic group who cheats us in a business transaction and we immediately ascribe his dishonesty in business to his race, forgetting that if someone of our own group cheated us, we would blame only the individual and have no thought of race. We see someone who is aggressive, and if he belongs to another racial or ethnic group we blame his race for it. It is a curious fact that we are less inclined, when we see something we like in a person of another race, to give his race credit for the asset, which, of course, is only an individual merit. Thus once a prejudice toward a racial or ethnic group gets started, it tends to be cumulatively confirmed by subsequent experience, and to blind us against all experiences that might prove the opposite.

*The Genesis of Race Prejudice.* Racial prejudice is associated with the disposition on the part of virtually every human group to think of itself as superior to outsiders. The notion of chosen people is quite widespread. We know of primitive communities the members of which call themselves "men" or "human beings" to distinguish themselves from all outsiders who are regarded as not quite human. We generally glorify the people whom we speak of as "we," whereas the "others" or outsiders are depreciated and suspected. Although strangers do sometimes

have a romantic fascination for us, more often than not we fear them and remain at a respectful distance from them, ready to believe almost anything about them to which we would not for a moment give credence if it concerned a member of our own group. Particularly where these strangers are distinguishable from our own group by such visible marks as color, the tendency to retain them in a category apart is persistent.

Racial prejudices may have their foundation in our own insecurity, be it economic or social. We are reluctant to enter into competition or rivalry with members of groups distinguishable from us by marked physical or cultural characteristics. And when we do compete with them, we are likely to attribute our own failures and shortcomings to some unfair advantage which the others are taking of us, or to our reluctance to put forth our best efforts against unequals. It has been repeatedly found by students of Negro-white relations in the South that the so-called white aristocracy shows less racial prejudice than do the "poor whites" whose own position is relatively insecure and who must compete with Negroes for jobs, for property, for social position, and for power. Only those who themselves are insecure feel impelled to press their claims for superiority over others. This is confirmed by the fact that racial prejudices and conflicts flare up most violently in periods of economic distress when there are not enough jobs to go around. Similarly, when an ample supply of housing is available, people will generally settle in areas where life for them is most congenial and where they can afford to live. But when housing facilities are limited, the Negro may find it difficult to obtain living space, especially when it involves displacing whites.

It takes an exceptionally objective person to accept responsibility for his own failures and frustrations. It is much more convenient to put the blame on another and to invent a scapegoat, especially if that scapegoat has already been groomed for the role by history and circumstance. In the southern part of the United States it might be the Negro; in the Southwest it might be the Mexican or the Indian; on the Pacific Coast, the Oriental; in the great cities, the immigrant or the Jew. We choose as whipping boys those who are easily accessible, easily identifiable, relatively defenseless, and who give us a plausible provocation by actual or imagined competition.

Once a prejudice has become established it tends to perpetuate itself. It becomes part of the atmosphere to which we are exposed from infancy on, not only by what we are officially taught, by what we read, and by what we hear in conversation, but also by subtle gestures and jokes. The desire to conform to what the "best people" do, believe, and say is strong in all of us, and if they happen to hold these prejudices, we tend, though quite unconsciously, to emulate them. Furthermore, these prejudices hold us at a distance from the victims of the prejudices. We never give ourselves a chance to meet on intimate terms those against whom we are prejudiced. If by circumstances we are thrown in contact with them and find no confirmation of our prejudices, we tend to regard these individuals as exceptional cases and still go on believing that others of that race fully deserve the treatment they get. On the other hand, when we meet a member of a race against whom we do not hold prejudices and find him obnoxious, we either never identify him with the group to which he belongs or treat him merely as an obnoxious and unfortunate individual. The groups against whom we hold prejudices, therefore, start out with an initial handicap in their relations with us which they are rarely given the opportunity to overcome. The burden of proof that they are not obnoxious and inferior is upon them.

Being thus regarded as inferior and being excluded from free association and from equal opportunities, the members of a racial group who suffer from prejudice may come not only to feel inferior but also, through unequal opportunities and rewards, actually to be inferior. Correspondingly, the holders of the prejudice may become confirmed in their smug feeling of superiority by being able to point to the evidences of their own superior achievement.

There is no evidence to show that race prejudice is any more inherent in human beings than tastes, preferences, and aversions in other matters. Race prejudice is not an instinct nor an innate tendency, but

an attitude which has to be acquired, a mode of behavior which has to be learned. Newborn infants do not have it. Young children are generally free from it, and such experimental evidence as we have leads us to believe that it can be both taught and untaught. The mere fact that in different parts of the world, among different peoples, in different epochs of history, and under differing circumstances these prejudices differ widely should lead us to see how modifiable they are.

*Factors Affecting the Decline of Race Prejudice.* It is relevant to ask, therefore, what can be done about these prejudices. The problem is not solved by the obvious and oft-given advice that we should get to know members of the other race more intimately. Unfortunately, to know all is not always to forgive all. The more intimate we become with one another, the more, to be sure, we shall understand one another, but it does not follow that the more intimate we become, the more affectionate we become. Intimate knowledge of others may lead us to like them more, but also to dislike them more than we did before.

Students of race relations have noticed that prejudice tends to decline when the group that is the victim of the prejudice is no longer in direct competition with the group that holds the prejudice. The greater the security of a group, the less provocation it has to generate and maintain prejudices against other groups. Some improvement in race relations, therefore, might be expected by minimizing or eliminating the causes of economic and social insecurity among all men.

It has also been found that it becomes more difficult to maintain race prejudice when the members of the group against whom the prejudice is directed are no longer easily identifiable, when the marks—whether physical or social—by means of which we classify and label them fade out. Since the Negro is so distinctly marked by physical traits, the prospect that prejudice toward him will disappear is less than the prospect of the decline of prejudice toward racial and ethnic groups less visibly different from ourselves. But even among Negroes, it should be noted that many thousands of mixed bloods are annually incorporated into the white group, or at least pass among the white group unrecognized as Negroes. The more anonymous our society becomes, the more likely it is that individuals can pass from one side of the color line to the other unnoticed.

Similarly, race prejudice tends to decline when enough exceptions are made. If we have the opportunity to meet a sufficient number of members of the group against whom a prejudice exists who are exceptional, then the rule to which they are the exception is undermined. Self-respecting individuals of a minority group will, of course, be reluctant to accept special treatment. They will not be flattered when someone says, "All Negroes are so and so, but you are an exception," or "I meant no harm, because some of my best friends are Jews." But if the person who holds the initial prejudice meets only persons of the minority groups who are exceptional and none who conform to his stereotype, the stereotype may finally give way. Just as we have attitudes toward Negroes, however, long before we have met a Negro, so we must not expect these attitudes suddenly to vanish once we have the evidence which contradicts them. As our experience which contradicts our stereotypes grows, there is at least the likelihood that our attitudes will eventually be modified. Education, therefore, as it enriches our experience, can become a factor destructive of prejudice.

We have had it reaffirmed recently, if we had not known it already, that race prejudice is likely to decline when the larger group, say the nation, is threatened by an external enemy. When there is an enemy without, the differences within are minimized. Thus, in a period of war we realize more clearly than ever before that racial, religious, and other prejudices constitute a danger to our national unity and it begins to dawn upon us that, however deep-seated our own internal conflicts may have been, they are as nothing compared with the conflicts between us and our enemies.

*Consequences of Race Prejudice.* Racial, ethnic, and religious prejudices can become seriously divisive forces in society. They are particularly demoralizing in a democracy,

where men profess to believe in equality of opportunity. They make our ideals seem impracticable and impossible of realization. They destroy our belief in our own integrity and our ideals. They tend to make us esteem our fellow men, not on the basis of their individual merit or contributions to society, but on the basis of some fact or alleged fact over which they have no control whatsoever.

Particularly when we are engaged in a struggle against anti-democratic forces do these prejudices become inimical to the national interest. If the dignity and autonomy of the human personality which we profess to respect means anything, it means that we confer status upon an individual, not by virtue of the group into which he was born, but on the basis of his performance. We regard this as one of the principal differences between a caste order—which we began to outlive when we abolished slavery—and a free society. Whereas in a caste order individuals and families occupy a fixed status from which they cannot escape and which they cannot and do not wish to alter, in a society like ours there is, theoretically at least, a possibility of relatively free movement up and down the social scale and there is the ever-present incentive to take advantage of this possibility.

By maintaining racial prejudices we make it possible for our enemies to say "You, too, regardless of your professions to the contrary, practice racial discrimination." What is more, the existence of these prejudices is a factor in undermining the loyalty of the group that is the victim of them. They prevent the nation from gaining the benefit of the maximum contribution and full participation of all of its members in the common cause. Just as they cripple the victim, so these prejudices also warp the holders. They make them blind to what they do not wish to see; they breed arrogance and bigotry; and not infrequently they lead to wanton aggression and unprovoked violence.

Despite the fact that there is no scientific justification for linking the physical characteristics that distinguish the major groups of mankind with intellectual or moral virtues or defects, this linkage constitutes the very heart of race prejudice. Similarly, although there is no justification in science for linking a given language, religion, class, party, or nationality with a given racial group, conflicts that are essentially economic, political, religious, or intellectual come to be regarded as racial. What we do not like about others in our economic, political, religious, and social intercourse, we can, under certain circumstances, attribute to their race. Race prejudice thus comes to be transferred to groups which may not be racial at all. The prejudices derived from one source can be used to reinforce and sustain the prejudices arising from a very different cause.

In the past, racial myths have been invented to account for the rise and fall of empires, to justify and to resist revolutionary movements, to rationalize slavery, war, and imperialistic adventures. Racial prejudices have been used to make discrimination in economic opportunities, in education, in immigration, and in social relations seem just and reasonable. They can be used to weld together peoples who have otherwise little in common, just as they can be used to tear asunder groups which history and a common social heritage have welded into a unity. They have been for a long time and are currently being used by our enemies as a powerful weapon against us in the present World War.

*Private and Public Prejudices.* While the race prejudices of individuals appear to be largely matters of private concern, they are by no means purely private, either in origin or in their consequences. To the extent that they are the product of the prevailing social stereotypes they can be modified as other collective images are subject to alteration by education and propaganda. They can be affected for good or ill by laws, official practices, and public policy. They can perhaps be dealt with more effectively by indirect than by direct attack, for they are deeply imbedded in the structure of our society and hence can be basically altered only as society itself is altered. Such prejudices do not flourish in a wholesome society where all the members enjoy a substantial measure of security, where no group feels itself exploited and dominated by another group, where group conflicts are at a minimum, or, if acute, are equitably resolved in accordance

with freely accepted rules of the game. In an orderly, stable, prosperous, and enlightened society these prejudices cannot very easily become widely diffused among substantial sections of the people. What is most important, however, is that in such a society it is virtually impossible to build organized movements upon them.

Race prejudices, like all attitudes, are not only contagious but are cumulatively reinforced by the day-to-day social interaction that goes on in a society. Eventually they crystallize into customs and not infrequently they are written into laws. When race attitudes become organized into social movements and thus acquire the vehicles of organizations, ideologies, symbols, and techniques for their dissemination and sanction, they become significant factors in the shaping of public policy. In this manner private prejudices become matters of utmost public concern.

*Evolution of American Racial Policy.* The United States has not been free from race movements; at different times and in different parts of the country different groups have been the object of organized race prejudice. From its first settlement to the present this nation has followed a succession of public policies involving race discrimination. Our earliest and most dramatic instance of public policy with reference to race emerged with the first contact of the white settlers on this continent with the native Indian population. The indigenous Indians, representing as they did an obstacle to white settlement, found themselves chronically in open war with the whites and were ultimately subjugated by the technically superior invaders. Until very recently the Indians were not allowed to share the rights of citizens, and those who were not exterminated were reduced to the subordinate status of wards of the government and confined to reservations.

Far more important than the Indian, at least from the standpoint of numbers, is the Negro minority in the United States. Ever since the day when he was first imported as an indentured servant or slave from Africa he has constituted the principal stock among our people subjected to both official and unofficial differential treatment based upon difference in race. Since the Negro constitutes nearly one-tenth of our total population and is the principal victim of racial discrimination, his treatment may serve to illustrate the relation between race and public policy.

Neither in the American Colonies nor in the newly formed nation was the Negro included among those who enjoyed the rights of citizenship and equal protection of the law. He was assigned to an inferior place and in general remained in the place assigned to him, although sporadic rebellions testify to the fact that he did not always meekly accept his position as permanent. During the period of slavery the Negro was effectively subordinated to the whites by custom, public policy, and law. To be sure, not all Negroes nor all slaves were treated alike. Some slaves either purchased or were granted their formal freedom. The house servants were on the whole in a more intimate personal relationship with their masters than were the field hands, and the treatment of the former was considerably more humane. But slaves were property and despite their unique human qualities, as property they were considered in a category apart from the rest of society. A body of law and judicial decisions grew up defining the relationship between whites and Negroes. These legal sanctions heaped upon custom constitute the principal body of race legislation in America. Among the earliest racial legislation are prohibitions of intermarriage between Negroes and whites.

In the course of the Civil War and the collapse of the legal and political support of slavery, the power, privileges, and authority of the masters were weakened. But formal emancipation did not bring either actual freedom or real equality. New laws were considered necessary to define the new relationships between the races when the old caste order collapsed. The nation's attempt to superimpose a new pattern of race relations upon the South and to force equality by law, as evidenced by the Reconstruction measures, proved unsuccessful and produced bitter reaction. Before the 14th Amendment placed limits upon the states, eight of them passed "black codes" to make the new status of the Negro coincide as nearly as possible

with the old. The "black codes" imposed restrictions upon Negroes limiting their choice of occupations and attempted to tie the former slaves to the plantation economy. They regulated labor and circumscribed the black worker's freedom of movement.

Among the legislation restricting the freedom of the Negro are the segregation laws, or "Jim Crow" laws, enacted by most of the Southern states. Under these laws the states which made any provision at all for the education of Negroes did so under the condition of the separation of the races in the schools. Similar separation was enforced in public assemblies, including churches, on common carriers, in hospitals, and in penal institutions. The Negro was further subjected to differential treatment in the courts; he was dealt with more severely under the statutes for committing certain offenses against whites, especially sexual offenses. In some jurisdictions he was excluded from juries and limited in his capacity to testify against whites. Negro suffrage, where it existed at all, rested upon unequal terms with white persons.

The 14th Amendment, which granted the Negro "equal protection of the law," was met by a negative response from the South and induced Congress to pass a series of Reconstruction acts beginning in 1867. Military governments were established in several of the Southern states and the existing governments declared illegal. The 15th Amendment, in 1869, was followed by a second series of Reconstruction acts, sometimes referred to as the "Force Bills," designed to lay a constitutional basis for the enforcement of the amendment. With the influx of carpet baggers from the North and the ascendancy of a strong Negro political organization in the South, some of the more flagrant anti-Negro measures enacted between 1865 and 1867 were repealed. Under the impact of this order imposed from without and flagrantly in conflict with custom and attitude in the Solid South, Southern whites rallied to consolidate their strength and even turned to extralegal means to regain supremacy. The Ku Klux Klan was merely the most prominent of a number of organizations that sprang up throughout the South to intimidate the Negro and to restore the dominance of Southern whites. The Democratic Party became the white man's party and managed in most of the Southern states to rewrite into the laws the repressive and discriminatory legislation which the 14th and 15th Amendments were designed to outlaw.

Among the legislation calculated to disfranchise the Negro was the so-called "grandfather clause," which limited the suffrage to those who were lineal descendants of persons who were entitled to vote at some point in time when Negroes were excluded. Since the Supreme Court declared these laws to be unconstitutional in 1915, other devices to restrict Negroes from exercising their right to vote have been resorted to, among them property requirements, the poll tax, and literacy tests which whites were allowed to circumvent but which were invoked in the case of Negroes. In addition, when other means failed, the Negroes were effectively debarred by intimidation from registration and voting.

*Contemporary American Racial Policy.* Both by custom and by law a Negro in the United States is today subjected to differential treatment in almost all aspects of life. Without attempting to treat all the forms and aspects of racial discrimination, it may be well to cite the principal fields in which the Negro today suffers from grossly unequal treatment.

On the political scene, the Negro in large areas of the South is still effectively debarred from the franchise. This is done not only through the poll tax, but also through his virtual exclusion from the primary by the Democratic Party, which in effect had come to regard itself, with the sanction of the courts, as a private social club. What applies to voting applies equally to the holding of public office. Even in the case of appointments under Federal Civil Service regulations, the Negro finds himself accepted only in inferior positions, and grossly under-represented, and where accepted, to a large extent segregated. This is even more true in the State governments, except in those Northern urban areas where the Negro enjoys considerable political power and hence can exact certain limited concessions from the patronage dispensers.

In the armed forces racial lines are clearly

recognized. The Negro soldier is on the whole strictly segregated into colored units. There are few Negro officers and they never command white units. Although in our earlier history Negroes had distinguished records in the United States Navy, only recently has the Negro again been eligible for our naval forces in any other capacity than as messboy, and he has not yet achieved officer rank.

Some governmental agencies on the Federal level have recognized the importance of race relations as they affect their specific activities and have appointed special personnel, such as race relations consultants, to deal with these problems. Valuable as their function has been, these race relations consultants, who are generally Negroes, are frequently put into the impossible position of having to serve as shock absorbers to protect the policy-making officials against Negro protest, while at the same time they are powerless to deal with the grievances of the Negroes arising out of unequal treatment and race discrimination.

In the awarding of war production contracts by the Federal government, in accordance with Congressional action, clauses have been written into the contracts prohibiting racial discrimination in employment. By executive order of the President a Fair Employment Practices Committee has been established to minimize discrimination against Negroes in defense industries, but unfortunately this committee has little power aside from the weapon of publicity to deal with violations.

Segregation legislation in the Southern states provides for "separate but equal accommodations" for the two races. In fact, however, separate accommodations have rarely meant equal accommodations. This "Jim Crow" legislation applies not merely to segregation in public institutions, but to private facilities as well, including places of amusement, restaurants, and even cemeteries.

Although there is ample evidence of discrimination against Negroes by legislative action, the unequal treatment of the Negro goes beyond the scope of law. Though in theory he receives the equal protection of the law, in fact he must suffer from virtual exclusion from juries, inadequate facilities for his defense, the prejudice of the police, prosecuting agencies and judges, who are generally white; and the disadvantages that come from unfavorable organs of public opinion, hostile public sentiment, and the ever present danger that if legal methods for denying him justice are not effective, mob violence will take its place.

That the Negro has suffered from unequal public services is such a commonplace fact that it hardly needs mentioning. A notable exception is the equitable treatment of the Negro under the Federal relief program during the depression, and under the provisions of the Social Security Act, save as in practice state and local administrators of these measures have been able to nullify the intent of the Federal government to avoid discrimination in relief and welfare measures. There is overwhelming evidence to show, however, that not merely in the South but in the North as well, the Negro has received inferior police protection, sanitary facilities, medical care, housing, recreation, and education.

It is particularly in the field of education that racial discrimination has been most widespread and has reacted most unfavorably upon the long-term prospects of attaining equality of opportunity for the Negro. It happens that the Southern states which segregate the Negro in the schools are also the poorest states and would be able to furnish only mediocre educational opportunities even if they had to maintain only a single school system. A dual school system, however, imposes increased financial burdens upon these economically disadvantaged areas and generally results in grossly inferior school facilities and educational opportunities for Negroes. This tends to perpetuate the already existing inequalities by depriving the Negro of opportunities to rise in the economic and social scale.

There is a long history in the United States of attempts to impose residential segregation upon the Negro by law and local ordinances. Recent Supreme Court decisions, however, have undermined the constitutionality of these acts, and, in the absence of suitable legal devices, property owners have resorted to private arrangements between themselves known as "restrictive covenants" which debar Negroes almost as effectively from free

choice of residence as if the segregation were enforced by law. As yet there is no definitive decision by the Supreme Court invalidating such private contracts on the ground that they are contrary to public policy.

Even where the Negro is not subject to discriminatory treatment by law he is nevertheless severely handicapped by custom and public policy. This is manifested in the singularly consistent imposition of unequal standards of merit and recognition accorded to the Negro in the professions. Even Northern institutions relatively free from public pressure, such as higher institutions of learning and professional associations, only rarely admit Negroes and offer them opportunities to make their contributions on equal terms with whites. With the possible exception of the arts, the Negro is thus made dependent upon the more limited rewards and recognition that he can derive from his own circumscribed racial group. If it is recognized that success in almost all fields of human endeavor depends not merely upon native capacity but also upon opportunity, hope of reward, and traditions of success, it can be inferred how severe a handicap is imposed upon even those Negroes who have superior talents. Under these circumstances it is no wonder that the economic, political, and cultural advancement of the Negro has been slow. Indeed the Negro has remarkable achievements to his credit in the face of these severe, chronic, and cumulative handicaps.

Discouraging as the prospect of attaining more nearly equal opportunities for persons irrespective of race might seem to be in this country, there are, nevertheless, some signs of a greater awareness of the problems involved and of a willingness on the part of the dominant white group, even in the South, to make concessions to the rising tide of democratic sentiment and enlightenment. Aside from Federal legislation and administrative policies already referred to above, the Negro's quest for equality of opportunity has been immensely strengthened in recent years by a number of Supreme Court decisions. Among these has been the reaffirmation on April 28, 1941, by unanimous decision of the Supreme Court, that Negroes traveling from one state to another are entitled to railroad accommodations equal to those furnished white persons, which while it does not specifically do away with segregation will compel interstate carriers to provide the same accommodations for Negroes and whites who buy first-class tickets. Another decision of May 26, 1941, held that Congress has the power to regulate primary elections in the same manner in which it regulates general elections, a decision which, while subject to greatly varying interpretation, may undermine the Democratic primary system of the South, which has debarred the Negro from the franchise. Of special interest are recent court decisions making it mandatory for states which exclude Negroes from higher educational institutions and professional schools to provide such education of approximately equal quality. A series of decisions in peonage cases and reversals of lower courts' decisions in criminal cases involving Negroes, on the ground that Negroes were excluded from juries and that the defendants did not receive fair trials because of their race, has served as a warning to local jurisdictions that the Federal constitutional provisions establishing equal protection of the law irrespective of race can no longer be so easily evaded. The public discussion that has resulted from the introduction of anti-poll tax and anti-lynching bills may be regarded as a further sign that the nation as a whole is concerned about the nullification of the fundamental laws by certain states and localities where these laws run counter to the racial mores.

The bold and outspoken statements of leading personalities and of organizations—including many in the South—in denunciation of racial discrimination are a further sign of impending changes. The development of the CIO as a new labor organization more nearly free from the established prejudices of the older existing labor groups also augurs well for the enhanced employment opportunities of the Negro on a basis more nearly equal to that of whites. This trend is strengthened by recent opinions rendered by the Attorney General holding that contracts between employers and unions discriminating against Negroes are invalid. The passage of more stringent civil rights legislation in such states as New York and Illinois, which recently have received large influxes of Negro mi-

grants, is another wholesome step. These laws provide severe penalties for deprivation of equal civil rights including equal accommodations in private commercial establishments. They provide further for punishment and damages for mob violence. They reaffirm the right of equal access to employment opportunities. The New York law forbids discrimination by life insurance companies on account of race. These steps are further indications of growing public awareness of the danger inherent in the spread of racial discrimination from the South to other parts of the country. They suggest a slowly emerging public policy designed to attack discriminatory racial practices generally.

*War Experiences and Post-War Prospects.* There seems little doubt that this recently accentuated awareness of the discrepancy between our national ideals and our actual practices and policies in relation to race is connected with the character of, and our involvement in, World War II. In a very real sense our enemies have thrust the race issue upon us. They have attempted to make this into a racial war, and the important question for America, therefore, is whether the Nazi doctrine of race and the practices that go with it shall make progress in this country and shall be allowed to divide us, to undermine our national solidarity, and to frustrate the exertion of our maximum potential war effort.

At first glance it would seem that in a country as diverse in its racial and cultural composition as ours, the propaganda of racism would have little prospect of succeeding and the practices of our enemy in respect to what they call inferior races would arouse universal horror and disgust. But we cannot talk out of existence the racial, religious, and cultural conflicts and prejudices which have flourished among us and which have given rise to organized movements of Nativism, Know-Nothingism, Ku Kluxism, and other movements of intolerance and bigotry. Our enemies have demonstrated the power of propaganda which can thrive upon latent attitudes of race antagonism and race mythologies, especially in times of crisis and under conditions of personal insecurity. We must expect our enemies to exploit the resentment that racial minorities feel against the restrictions of their constitutional rights to vote, to enjoy the privileges of citizenship, and to receive equal treatment under the law; against discrimination in employment and in public conveyances; against deliberate segregation; against unequal educational opportunities; against the blocking of their paths of personal advancement; and against not infrequent mass violence.

Unfortunately, the stark necessities of war, while they have made us more conscious of the promises of democracy, have also frustrated our ability to fulfill them. Indeed, we have resorted, perhaps unnecessarily, to measures which have widened old and generated new forms of racial discrimination. We have, for instance, indiscriminately herded Japanese residents, irrespective of their citizenship, into relocation centers and thus nullified the dignity of American citizenship and subordinated it to the criterion of race. We have deprived a substantial part of our citizenry, solely on account of race, of the privilege of contributing its full measure of strength to the winning of the war.

Among the bulwarks upon which we rely to protect us from being engulfed by racial prejudices are those found in the Preamble to the Declaration of Independence, in our Constitution, and in the Bill of Rights. There are few peoples in the world who have affirmed as high a set of principles as these to guide their public policy. Far as we have been from actually realizing the ideals expressed in these noble state documents, they do nevertheless constantly remind us that as a nation we cherish the principle of the equality of men before the law and equality of opportunity for all. We know that not all men are born equal and certainly not all are treated as equals, but we have set equality down as a goal toward which to strive and as the criterion for determining the soundness of public policy. We are at least sure of the direction in which we want to move as a nation.

Race relations policies for any nation are no longer a matter of purely domestic concern. They are issues that concern the world as a whole and they will inevitably be an important phase of the task of post-war world

reconstruction. All the caste-like arrangements subordinating the colored races to the white group are rapidly crumbling under the impact of the inevitable and increasing contacts between peoples generated by the spread of urban industrial civilization. The ideals of freedom and human equality embedded in the religious and political heritage of occidental society, which were given new impetus by the American, French, and Russian revolutions, have continued to fire suppressed peoples everywhere with the ambition to improve their status. The protest against exploitation and subordination of one racial group by another has become world-wide. It has awakened the conscience of the dominant groups in all parts of the world to the indefensibility of their exclusive prerogatives based upon race. In the course of the struggle against fascism and its accompanying dogma of racism, the democratic ideology has acquired new vitality. The value of racial equality has acquired such political force in the world that even such nations as Japan in the course of the war have found it advantageous to grant at least nominal freedom to some of their conquered territories in order to make our own promises of freedom to these peoples seem hollow and hypocritical.

Fortunately, our record in the period immediately preceding the World War offers ample demonstration of the fact that we did not need the impelling motive of military expediency to adopt a more enlightened racial policy. Our action toward the Philippines, for instance, lends strength to the belief that we can resist the temptation to impose ourselves as imperial masters over other peoples and that we can win their loyalty and friendship through improving their lot to the best of our ability. Our recent efforts to improve the conditions of life of the people of Puerto Rico, coupled with the suggestion by a responsible official that they be given the right to elect their own governor, offer similar testimony of our decent intentions. Our relinquishment of extra-territorial rights in China and Congressional action eliminating Chinese exclusion, though beclouded by the fact that these actions were taken under the pressure of war, constitute other proof.

In our own country we have been making strenuous efforts through a more enlightened policy toward the Indian to make good the injustices which were done him. In the case of the Negro, the virtual disappearance of lynchings, the improvement in education, health, housing, and welfare, the resolute steps toward actual enfranchisement, the improvement in the administration of justice, and the provision through official and unofficial action of greater employment opportunities are other encouraging signs that have received widespread public support. What is most important of all is that for all minorities we have shown increasing concern to keep the door of opportunity open.

While we are far from having eliminated distinctions in law, custom, conventions, social usages, ritual, and etiquette based solely upon differences in race, we are in our public policy definitely moving in that direction at a faster pace than we have ever done before. It must be recognized, however, that public policy is shaped by the citizenry and that official action cannot in the long run be either too far ahead or too far behind public sentiment and opinion. The public sentiment and opinion that will ultimately shape both public policy and private conduct is becoming more world-wide in scope. America for centuries has been the experimental proving ground for the principle that men irrespective of their race, creed, or origin can live and work together harmoniously for the common good. If we as a nation can keep alive the struggle for the fuller realization of the ideals which we have as yet only imperfectly achieved, we shall gain an immense source of strength against the enemy and we shall have a more certain prospect for building a better world for all mankind.

# MENTAL DECLINE AND ITS RETARDATION

By GEORGE LAWTON

We all want to maintain until death the physical, social, and mental effectiveness of early and middle maturity. Anyone who could find a way of permanently arresting decline in any area of human activity, would be discovering a fountain of youth; but I do not report any such discovery.

Throughout human history both physical and mental rejuvenation have been sought through physiological agencies, and this is the main trend even today. However, we must investigate the extent to which we can reverse and retard mental decline solely through psychological techniques. This is a problem which respectable psychologists seldom consider, for it is not easy to free the topic from its association with magic and charlatanry.

## I

Intelligence, that entity measured by intelligence tests, matures between the ages of thirteen and sixteen, and stays on a level until the early twenties. Though we gain mental stature quickly, we lose it slowly; for the gain in ability of the last three years of mental age growth (13 to 16) is gradually lost in the next sixty years, with the larger portion of the decrements coming in the forties and sixties. By the age of fifty-five we have receded to the fourteen-year-old level.

However, if we separate the different abilities involved in the total functioning called *intelligence,* we find that each ability has its own rate of decline and its own degree of susceptibility to remedial measures. Peak levels in physiological functions are reached earlier than in psychological ones. Hence, the more a mental activity includes a physiological factor, the more it declines with age.

In what follows, mental abilities will be spread out in a kind of spectrum, starting with those mental abilities most dependent on physiological function, and ending up with those least so.

*Vision and Hearing.* These functions—non-mental but a necessary foundation for mental ones—reach their peak in our late teens and decline slowly. At the age of fifty, there is normally a degree of hearing impairment for higher tones sufficient to affect ordinary conversation. Visual efficiency at the age of sixty is ten to twenty percent less than at forty.

*Reaction Time.* This is a combination of speed of perception, involving the senses of sight and hearing, and the rapidity of muscular function. It reaches a peak in the late teens or early twenties. Of all the mental abilities, it is the most dependent on physiological function and therefore shows the most marked loss.

Life gives tests of reaction time when psychologists do not. In automobile accidents involving pedestrians, two thirds of those killed are over forty. However, in an experiment of W. R. Miles, twenty-five percent of the seventy-year-olds had a reaction time equal to the average of the group, the latter covering the entire age range.

*Immediate Memory.* Although this ability reaches its peak in the late teens and early twenties, it declines rapidly with age. Forgetting recent events is one of the classic indices of senescence.

*New Learning.* The work of Thorndike, Miles, and others has shown that the ability to learn new things reaches its maximum in the late teens and early twenties and then starts slowly declining.

Jeanne G. Gilbert in a study of sixty-year-olds also reports that the type of learning in which loss is greatest is that of "paired associates." The more a task differs from an already existing habit pattern, the greater the loss in ability with age. However, immediate reproductive ability, such as making simple repetitions, shows relatively slight loss.

*Old Learning.* If vocabulary is taken as an example, old learning declines little or not at all with age, first, because as earliest formed material it is not much affected by physiological decline. Second, it is learning that is constantly exercised.

*Judgment and Reasoning Ability.* This

develops slowly in general or in a given area, reaches its peak latest of all abilities, and is among the last to go.

The strategy of tackling problems often improves with age. Harry De Silva, an authority in the driver testing field, observes:

> Although this decline in reactive time is important and should be recognized and allowed for by persons as they grow older, it has too often been exaggerated. The older person's improved judgment, better emotional control and coolness in the face of emergencies, usually more than offset the slight loss of sensory capacity and motor control. In tests of adaptability and vigilance, older experienced drivers invariably rank higher than young ones.

In driving accidents, it is the young age groups that are mostly involved. In industry, the carefulness, good judgment, and experience of the older worker lead to a lower accident rate. We must note Pressey's caution, however, that in any factory there is a continual weeding out of the unfit.

*Creative Imagination.* This apparently undergoes little or no decline. Through the use of the Kinephantom—a revolving fan whose silhouette appears like an animated ink blot—W. R. Miles found that younger and older individuals in an average population achieved practically the same scores.

Creative thinking has been studied by Harvey C. Lehman. For several kinds, such as in philosophy and medicine, the peak levels of achievement are at the age of thirty-five to thirty-nine. In music, some composers reach their height between thirty-five and thirty-nine, others reach theirs between forty and forty-four. Military leaders and authors of best books also reach their peaks between forty and forty-four. But the top of the political ladder is most likely to be reached by men who are between fifty and fifty-nine. While Lehman would place the peak of human physical strength and skill at about twenty-seven to twenty-eight, leadership in business and in politics is achieved thirty years later.

Where the unique creative product depends largely on physiological activity, greater achievement will come earlier; when it is more dependent on psychological factors, it tends to appear later. Dorland shows that the average age at which the masterpiece was produced runs as follows: physicists, forty-one; inventors, poets, dramatists, and playwrights, forty-four; novelists, forty-six; explorers and warriors, forty-seven; actors and musical composers, forty-eight; artists and divines, fifty; reformers and essayists, fifty-one; physicians, surgeons, and statesmen, fifty-two; philosophers, fifty-four; astronomers and mathematicians, satirists, and humorists, fifty-six; historians, fifty-seven; jurists and naturalists, fifty-eight.

It is Lehman's view that individuals may make invaluable creative contributions at practically every chronological age level beyond early youth. Woodworth also states: "Another condition favorable to invention is youth, with its openness to new impressions and its radical tendency to do something different from what has been done before. But maturity also is necessary for socially important creative work. . . . It would be foolish to draw a dead-line anywhere."

## II

Few people live long enough to undergo severe obsolescence of *all* abilities and functions. We therefore should speak not of an aged person, but of an aged ability, function, or adjustment, whether it be physical, mental, emotional, social, or vocational.

However, as long as we include speed factors in our appraisal technique we will discover a difference in efficiency between a group of persons in the sixties and one in the twenties. Miles found that by the age of seventy there will be an average decrement in strength, skill, and sensory acuity of one fourth to one third from the twenty-five-year-old average.

If we eliminate speed and consider only mental power, however, the difference between older and younger individuals is reduced. Intellectual persistence—a non-speed factor—does not show age decrement. Even with regard to mental efficiency, individual differences may be as great at the older ages as at the younger. In most types of work, the decrease should not be important and might well be more than balanced by greater experience and dependability. As Pressey says, "To the average person, it is of little practical importance that he can not run as fast at sixty as he can at thirty;

at all ages, the usual pace in self-locomotion is the walk."

Only a small number of individuals in the sixties under present educational and vocational conditions are capable of attacking with normal efficiency (i.e., as speedily) tasks involving new learning suited to their native intellect. Nevertheless, age alone is not a sufficient factor by which to judge efficiency in any particular work, since judgment, better integration of knowledge, and practice over a long period of years will compensate for losses in motor dexterity and sensory acuity. The older individual retains almost unimpaired his capacity for solving *mental* problems of difficulty equal to those he could solve when younger.

Older men generally are not suitable for pursuits that require long periods of sustained physical activity, exposure to danger of bodily harm, dexterity of the hand, or ability of the limbs. But when we need a thoughtful application to a particular task, older workers can serve as well as, or better than, younger ones. The indiscriminate shelving of men and women merely for age inflicts a loss upon society and the individual. If we shift workers from those jobs involving speed and strength to those involving skills which decline slowly with age, we can continue to utilize in industry many older men and women. Any defense plant today can provide examples of this. Let us hope the lesson will not be forgotten when the war ends.

## III

The first to show that we can retard and even reverse mental decline was Dr. Lillien J. Martin, who at the age of sixty-five started the San Francisco Old Age Counselling Center. Until her death at ninety-two on March 26, 1943, she was still actively engaged in her consulting work with aged clients. The writer is fortunate to have concluded a period of study with her only two weeks before her death and to have had access to her case records.

Existing proof that mental decline can be retarded is clinical rather than experimental and is to be found mostly in Dr. Martin's records. For her clients she devised a suitable psycho-educational remedial exercise for each mental ability that showed deterioration and for which the prognosis of reversing decline seemed good. For each pattern of living that handicapped the old person in his relationship to people or his job, Dr. Martin tried to point a way by means of which the client could achieve a new and better pattern. The criterion for success at the Old Age Center has been a pragmatic one; for example, the individual got a new job, or did better on the old one, or established more pleasant and effective relationships with members of his family.

My own readjustment work with the aged has convinced me that retardation and reversal of decline is possible. I find that least amenable to psychological techniques are those abilities with a large physiological component; most amenable are those that are largely mental.

However, psychologists doing rehabilitory work with older people find that even physiological deficits can be outwitted through suitable strategies or compensations. Every deficiency has two aspects, one the deficiency itself; the other the way it is used. Which will it be: to overcome or to be overcome by the effect of one's losses? The attitude toward the declines shown by the individual involved and by society act and react on each other. If the individual disregards the changes that can be disregarded and develops substitute physical facilities or patterns of behavior for those changes that cannot be ignored, the world is more likely to accept the aged individual at his own valuation; the converse is also true.

Pressey points out that world records in most sports continue to be broken. Some of this improvement is due to the better methods of training. A number of athletes, moreover, have had to overcome physical handicaps in order to achieve championship distinction. If effort, practice, and ingenuity can bring about such gains in sports, there are unsuspected potentialities in almost everyone. An older person determined to utilize his resources to the maximum might raise his level of fitness to a degree now thought impossible.

Physiological changes are largely responsible for the inability to make fresh mental associations. Old people talk more about the past partly because it has been better re-

corded, but also because their younger days are more emotionally toned, more tied up with a period of life in which hopes and desire for achievement and activity were at a maximum, and were either dramatically gratified or frustrated. Youth, finally, is a time when most persons have more emotional security and warm parental love than ever after. An older person who in the present has an opportunity to function and in it receives love and approval, does not need the past as a crutch. He will remember events in the present because he belongs to it and it belongs to him. Psychotherapy possesses great power to unhinge the old person's overdependence on his past.

While there is a decrease in the amount of learning which persons acquire as they grow older, there are minds which, because of great inner incentives, are able to amass knowledge until the most advanced ages. But even ordinary persons, as shown by Thorndike, Miles, and others, have far more ability and learning capacity than they ever utilize.

Some of the decreased physiological receptivity to new learning can be compensated for if an old person is compelled to be interested in it, as under wartime stress. The older person often pretends to be impervious to the world about him because he regards it as a threat. Many a senescent exaggerates his sensory loss in order to escape or to punish a world he believes does not like or understand him, a condition often caused by the fact that he has allowed it to grow unfamiliar, and unfamiliarity, as we know, breeds contempt.

If we reject people vocationally in middle maturity, and give them no opportunity or reason for learning, we cannot be surprised by the results in late maturity. The older men and women working in war industries or engaged in civilian defense have demonstrated a usefulness that except for the war might never have been realized, either by the community or by themselves.

## IV

Part of the ostensible mental loss of older persons is simply the piling up of poor work habits; a job or life situation is of a treadmill type. If activity is essential to the preservation of mental ability, this is an additional reason why retirement is unadvisable for many older people, and why every union and every professional organization should have a department which will plan for retirement *to,* not retirement *from.* People should be retired not on a particular day, but over a period of years by means of a stepping-down and retraining process, and through the medium of a job reallocation bureau, operating within the industry or profession itself. Someday every community may have its schools for older people with courses of study designed for the special needs, interests, and abilities of men and women in the sixties, seventies, and even eighties, and with vocational guidance counselors doing a tailor-made guidance job for individual old people.

Ultimately we also shall have to develop a whole repertoire of ways to utilize the judgment and experience of older people, whether these be in an advisory and teaching capacity, in the field of family and home relations, in industry, or in some work of an educational, social service, or recreational character. Advisory functions might be exercised within the family, but since the generations in our culture are not always amicably disposed toward one another, a clearing house by means of which an older individual might find young people to guide would help keep his interest alive and his mind active. Instead of pitting age against youth, we should strive to realize the potentialities of each. Cooperation, rather than competition, will bring out the best in each age grouping.

A good emotional adjustment is essential to continued utilization of whatever mental efficiency one possesses. Many factors which are unrelated to age or to intellectual decline as such, may lead to a pseudo-senescence. Some of these are: family dissensions; feeling of inadequacy; pressure, real or imaginary, from a superior or from youthful competition; money difficulties; an insecure job; unemployment. It is fear of aging, rather than the aging process itself, which often causes a functional loss in the mental realm.

We cannot dissociate intelligence from such other factors as motivation to learn, pressure to utilize fully what has been learned, and environmental opportunity. As Lehman points out, how can we motivate the

older individual as well as the younger one if the oldster has attained many of his life goals or if at some arbitrary age he is compelled to stop having goals? Does our civilization offer the older adult the same intellectual diet and opportunity to learn as it does the younger adult?

It may be that some old people are either unable or unwilling to assimilate much new experience. But before we accept this as a psychological law we must discover how much new experience our culture makes available for them. Our society does make a slight attempt to meet the custodial, economic, and medical needs of older people. In peacetime, however, we make no attempt to provide for their mental stimulation and thus contribute to the preservation of intellectual abilities.

The best solution is to have at presenescent age levels continuous adult education, and recreational, vocational, and personal guidance. A program providing for the individual's time during the post-employment period should be drawn up by management and worker while the latter still is employed. The old person who, while not physically incapacitated, wants to spend all his time "resting," is a neurotic now grown old. This he does either because of past failures, fear of future ones, or because he feels his efforts will be inadequately rewarded. The rocking chair type of senescent needs either vocational guidance, psychotherapy, or both. What he gets today is a better rocker.

The ideal situation for preserving mental abilities is one where an old person is provided with moderate economic security and medical care, but where he is constantly being compelled to face and solve problems that tax him to his mental limits though not beyond. Retirement allowances, medical care, institutions, homes—these no more meet the total mental, emotional, and social needs of older people than the same facilities would meet the needs of children.

Best for old people would be real jobs, real family relationships, real and challenging tasks in a civilization that needs them and wants them. But if men and women over sixty cannot be given lives that are real, they must have them by proxy. The aged need schools, recreation centers, arts and crafts centers, sheltered work shops, adult playgrounds, marriage brokers, social clubs. They need bureaus for the exchange of services. They need to adopt, spiritually, young people and whole families; they need volunteer and part-time jobs. Recreational and creative activity, personal fulfillment, edution, drawing from society and contributing to society—none of these, no matter how achieved, need ever end.

The late Earl Balfour, as he lay dying, whispered: "This is going to be a great experience." To meet every changing vista or circumstance in terms of its power, not for hurt, but for enlightenment or stimulation, is to be prepared for waning physical powers, loneliness, misfortune, or mental decline.

# THE SCHOLAR AS TEACHER

By RALPH F. SHANER

AWAY back in 1913, when I took up Biology at Lafayette College, I underwent an unforgetable experience. Professor Alvin Davison did not teach as other men do; he led us to teach ourselves. He divided the substance of each course into topics which he assigned to the students in turn. For example, he assigned me the teeth of the cat. In the laboratory stood a small box of ordinary index cards. On one of these I found a few general directions and references. With no other guidance, I bent over specimens and books for a week. On the appointed day I was the professor for fifteen minutes. I demonstrated my specimens with the aid of blackboard drawings, self-made charts, and any other device I could think of. Each of the students of the class presented a similar report in rotation throughout the two years of the course.

I doubt whether Professor Davison gave a half dozen formal lectures. One was a substitute for a final examination. We had no tests or final examinations. Attendance at the laboratory was not checked. The students might be anywhere collecting material or making field tests. Microscopes, books, and reagents stood on their shelves to be taken down at will. The door of the building was never locked. It was a common sight to see a lone student busy late at night changing reagents or transferring cultures.

Biology was not an easy course. The industry of the "cat lab" was proverbial. The professor seemed busy with his own affairs, but he knew all that happened. The slacker was reproved, and the puzzled worker was given timely help. We students did the rest.

The reader will recognize the similarity of Davison's method to the innovations of ultramodern progressive educationalists. Davison never claimed any originality; he remarked once that he had been brought up in it by his own teacher. The method was not new with his teacher, either. On the contrary, it has a history of some length and significance to American higher education.

For its origin one must go back to Ignaz Döllinger (1770–1841), Professor of Anatomy at Würzburg and Munich. A man of extraordinary scholarship and technical proficiency, Döllinger is remembered chiefly for his pupils. His own son was the celebrated theologian who suffered excommunication for leading the opposition to the adoption of the doctrine of Papal Infallibility. His sons in spirit were Purkinje, Pander, Martius, von Baer, and Agassiz, every one a great man in the natural science of the first half of the nineteenth century.

Döllinger's method of teaching is described by his most famous pupil, Karl von Baer, the founder of the science of embryology. Von Baer was educated as a physician at Dorpat in his native Esthonia. His medical course was interrupted in 1812 while he served as medical officer to the German contingent of Napoleon's army on its march into Russia. The horrors of the campaign turned von Baer from medicine to natural science. Someone suggested that he apply to Döllinger at Würzburg.

Taking a parcel of mosses as an introduction, he presented himself to Döllinger:

> I gave him the package of mosses from Martius and explained that I wished to study comparative anatomy under him. "I do not lecture on comparative anatomy this semester," replied Döllinger as he opened the package with his characteristic calmness and deliberation and began to look them over. I was thunderstruck. Döllinger looked over the mosses a while, and then noting that I still stood there, turned and looked me over a bit, and continued with his same deliberateness, "But why lectures? Bring some animal, any animal, and dissect it here, and after that something else."

Casting about for material, von Baer happened upon a leech at an apothecary shop. Döllinger gave him a few directions and then left him to his own devices. The first dissection was a crude affair. Döllinger then brought him Spix's monograph on the leech to show him how the dissection should be done, and directed him to repeat the work. In this manner von Baer progressed from animal to animal. At each step Döllinger

lent him some standard monograph, gave a little advice, and then left von Baer to work things out himself. In the same casual way Döllinger led von Baer into the new science of embryology and started him on his life work.

Von Baer was what would now be called a graduate student, but much the same system of teaching prevailed in the undergraduate course in anatomy at Würzburg. Dr. Hesselbach, the junior professor, carried the method to extremes. Beyond preparing a model dissection, he refused to give any directions. When asked for advice he only pointed out to the student the part that should be dissected further. He behaved as if he were dumb.

When von Baer came to teach anatomy at Königsberg, he introduced the modern lecture-laboratory method of instruction. His opinions on teaching methods are worth reading:

As a rule a lecture provides little more than a stimulus for the listener. Real fruits come only from self-application. If the lecture attempts to give facts to be stored in the memory, whether by pictures or by words, they do not sink in very deeply at the time and certainly are more quickly forgotten than when one takes pains to imprint them, and learns them by lingering over them long enough to become thoroughly familiar with them.

The student working by himself will need very much some judicious guidance in general theoretical concepts and in the making of observations, and the guidance must be that of an experienced and discerning man who is completely at home in the subject. I do not consider the Professor superfluous, after having been one myself so many years. I do think, however, that he should aim more to teach the students to teach themselves than has hitherto been the practice in some courses.

Instead of demonstrations by the instructor (which I consider only harmful), I had the student demonstrate his finished preparation to me. I gave the student help only when he showed that he had tried to find his own way. Every student should have his text beside him.

The writings of von Baer exercised great influence upon Huxley. Huxley introduced von Baer's methods into his teacher training class about 1870, and thereby started a revolution in science teaching in England. One of Huxley's demonstrators was H. N. Martin, who later came to Johns Hopkins and carried the method to America.

Shortly afterward, F. P. Mall became the first Professor of Anatomy at Johns Hopkins. Mall was also a great admirer of von Baer. Mall reverted to Döllinger's original plan and dispensed with lectures almost altogether. The reaction of the students is described by Gregg:

Just after that conversation I saw in the street a student I had known when we were together at a boys' camp. I taxed him for information about Hopkins. "Oh it's wonderful," he said, "and what teachers,—Welch, Howell, Abel, . . . all except one." "Is that so," I replied, "and who is he?" "Oh his name is Mall. Do you know what he did the very first day in Anatomy? He said, 'Gentlemen, the dissecting rooms are open from nine in the morning till ten at night. I can recommend the three following textbooks. There will always be some one there to help you if you get stuck, and when you are ready to take the examination, let us know.' Now if you can beat that for a ——— of laziness you're going some."

Mall began his work at Hopkins in 1893. The storm he raised in medical education still rages.

The spirit of Döllinger came to America even more directly through Louis Agassiz. Agassiz lived with Döllinger in his later Munich days and, like von Baer, acquired a lifelong interest in embryology and in original ways of teaching. Agassiz, as Professor at Harvard from 1847 onward, exerted a powerful influence in college science departments of his time. His way of dealing with students is illustrated by the following anecdote of President Eliot:

William Sturgis Bigelow, son of the eminent surgeon, Henry J. Bigelow, went through the medical school between 1871 and 1874, but at graduation was not sure that he wished to be a doctor or a surgeon. One day he said to his father: "I want to study some more natural history before I decide to be a practicing physician. I want to go to Professor Agassiz's laboratory and study under him." His father thought the son's scheme was foolish, but that he had better try it. On the first day Agassiz gave him a trilobite and said to him: "Look carefully at this trilobite and describe in this notebook everything you can see on this fossil." He said nothing more; and young Bigelow worked all morning on these directions. In the afternoon Agassiz appeared again at Bigelow's desk and remarked: "That's pretty good so far; but you haven't finished by any means. Go right on." Young Bigelow put in all the afternoon. The next morning Agassiz came in again and remarked: "Bigelow, you are getting on. Keep right at it."

Agassiz was a research man of very first rank, a profound scholar, and gifted lecturer. He trained a whole generation of American

teachers of natural science. He was in all likelihood the source of the teaching methods used by Davison at Lafayette.

It appears then, that some modern trends in education have a quite respectable history, and one long enough to afford a basis for evaluating some present-day proposals.

There is little question that students in general college courses would benefit from fewer lectures and more self-study. One who has not passed through such a course as we had at Lafayette cannot appreciate the mental exhilaration and abiding interest in scholarship that we acquired. What we taught ourselves, we learned forever. What the other students taught us may have faded, but we know how to get it back again. No finer training for life or for later teaching can be conceived.

But for technical and professional students the case is otherwise. Life is too short, the amount of exact information needed is too great, and the significance of much of it too remote. A skillful lecturer is needed to guide the student through the maze of detail, to put first facts first, and to supply a temporary sustaining interest, that the student may hold his knowledge until experience provides a permanent interest. Much must be learned by rote. Why apologize for rote learning? Man and animals learn the fundamentals of daily living by rote, and understand why things are done so afterwards. It is the only practical way to learn many things.

Students and circumstances vary, but one thing is always needful: a teacher who is *ein erfahrener und umsichtiger Mann der in der betreffenden Disciplin vollkommen orientirt ist*. There is no substitute for critical scholarship and common sense. Research ability is a noble attribute of any teacher, but the glamor of published papers must not blind us to the truth that original investigation benefits the teacher and his students only in so far as it enriches and refines his critical scholarship. The savant deserves more recognition than he is accorded in our colleges and universities.

What shall we say of the teacher who deals out the dregs of old subjects in neat new packages, attractively labeled, and who knows as much of what he teaches as the salesman does of the goods he sells over the counter? The salesman as teacher is a new phenomenon. He may impress business men, but hardly their children, unless students are different from what they used to be.

## PLANT BREEDING BY INCUBATOR METHODS

NOT unlike the famed Caesarean section and the incubation of immature animal embryos is the technique employed in plant breeding whereby the embryo is dissected from the mother fruit during the growing season and placed in an "incubator" under aseptic conditions, properly nourished with various salts and a sugar supply, with the result that a new individual is produced—an individual which might otherwise have perished.

An illustration of its usefulness is provided by the plant breeder working with the stone fruits—the peach, cherry, plum, and apricot—and who is breeding for early-ripening varieties of these fruits. When crosses are made in which a very early-ripening variety is used as the female parent, a high proportion of abortive embryos are produced. In fact, no viable embryos have ever been secured from crosses involving certain varieties as female parents. To be sure, a fruit may be produced in the crossing, but when the pits are planted no seedlings develop.

In nature, accordingly, evolution is blocked in the direction of breeding for still earlier-ripening varieties of these fruits. Both the fruit grower and the housewife will attest to the greater natural abundance of late-ripening varieties than early-ripening sorts. Late-ripening varieties tend to reproduce other late-ripening sorts, but the early-ripening varieties tend to eliminate themselves by their failure to produce viable seed. But, by the employment of the incubator technique, it is possible to breed in the direction of varieties ripening still earlier: it becomes practicable to use early-ripening varieties for both parents, to cut the resulting embryo from the mother fruit during the growing season before the embryo has disintegrated, to culture it by incubator methods, and to develop fruiting trees which may be the forerunners of new varieties ripening even earlier.

The technique in detail calls for the use of some suitable incubating chamber, such as a $\frac{1}{2}$-ounce glass bottle with metal screw cap, which must be both sterile and clean so as to be free from any possible source of contamination. Into the bottles is placed a nutrient solution containing certain essential salts and a source of carbohydrate, such as glucose, plus an agar gel as a surface upon which to grow the plant, since the embryo does not develop when submerged. A $\frac{3}{4}$-percent agar gel has been found sufficiently stiff to support the embryo on the surface, and yet sufficiently soft to permit easy penetration of roots and easy withdrawal of moisture and nutrients for growth and development.

The fruit is brought into the laboratory during the growing season at about the stage when by examination it has been found that the embryo is checked or aborted. The fruit is washed and carefully opened, exposing the seed. The seed itself is then carefully dissected so as to remove the seed coats and other enclosing tissues, and the naked embryos are removed and placed in the sterile incubator bottles.

Two methods have been used; namely, one employing a disinfectant of 2 percent chlorine solution and another in which no disinfectant is used. While in the early years of study a disinfectant was found essential to free the culture from contamination, later developments have made it possible to remove the embryo under aseptic conditions without the use of a disinfectant. Growth is similar by both methods, the latter being superior for young embryos and for delicate tissues.

After a few weeks in the incubator bottles, and when the embryos have developed sufficient shoot and root to support the young plant, the new individuals may be shaken from the bottle and transplanted to sterile sand supplied with a nutrient solution. When the plant has reached sufficient size in the sand, it may be transferred to soil, and finally placed in the open field for development as a tree. Peach, cherry, plum, and apricot embryos grown by this method have developed into vigorous trees which have borne fruit. In fact, so successful has the method been that one large nursery firm in

California employs a plant breeder to use it in order to develop varieties of peaches needed by Southern California horticulture.

But this is only one specific instance. There are others. For example, crosses between different species of plants are often unsuccessful owing to failure to develop viable seed—an obstacle frequently traced to physiological upsets and early abortion of seed and embryos. In such situations the embryo culture technique has been applied most successfully. For example, species crosses between different taxonomic sections of Prunus have given 72.5 percent germination by embryo culture methods and only 4.8 percent germination without such aid. Still further, 26 out of 62 attempted subgenera crosses of Prunus—still more distantly separated then sections of Prunus—have been made successfully by embryo culture, as compared with only 3 out of 304 without surgical assistance. The lily, too, has responded well; 15 species crosses have been made which have heretofore been listed as failing to produce viable seed. In the same manner many genetically possible but hitherto unobtainable crosses have been realized.

In all the successes so far reported with non-viable or abortive embryos it appears that the growth of the embryo is normal up to the time that a check occurs in its development, and that this checking is often associated with an interruption in the food supply and is a starvation effect. Accordingly, if an external source of food is provided under conditions favorable for growth, normal development continues.

So optimistic a picture requires considerable qualification. There are many instances in which embryos have failed to develop normally in culture. When embryos of some plants have been excised from the fruit fairly early in development, they have remained in a living and yet arrested stage for months under the conditions provided. In other instances they have developed curious growth patterns, characteristic of the age of the embryo when removed from the fruit, but not at all typical of the plant from which they were excised.

Much progress is being made in improved conditions of culture and in nutrients provided. For example, coconut milk has been found favorable for embryos of the Jimson weed, and young pine embryos have responded to heteroauxin and thiamin. Experiments so far made indicate some degree of usefulness of embryo culture for breeding the following plants: tobacco, tomato, radish, Jimson weed, cotton, lily, violet, gingko, pine, cherry, apple, pear, peach, plum, apricot, rose, and olive.

Quite aside from its value in growing embryos which are otherwise non-viable, the embryo culture method has been useful in speeding up the breeding program with certain plants whose embryos normally do not germinate as soon as they mature. For example, the seed of the rose and of many tree fruits must be after-ripened at a temperature of about 41 degrees Fahrenheit under moist conditions for a period of 6 to 16 weeks, depending upon the plant. Such seed does not start to germinate until the second season after the cross has been made. But by the embryo culture technique it is possible to germinate embryos even before they have become fully mature and thus to speed the number of generations secured in a given interval of time. In fact, it has been demonstrated that roses can be hybridized in September, the immature embryos excised and cultured in December, and the resulting plant brought to flower by April—all within a 7-month period.

There are as yet many unexplored possibilities for application of the embryo culture technique, and many challenging questions are raised. For example, what is the status of a plant which has heretofore been considered sterile in nature and which by culture of its non-viable embryos produces viable seed?

And finally, many interesting relationships are found between the development of plant embryos and animal embryos. Because of the nature of the material, the incubation of immature plant embryos offers opportunity to observe embryos in large numbers at various ages and stages of development. Studies of the growth patterns produced and of the nutrients and cultural conditions required promise to throw light on animal embryology.

H. B. Tukey

## SOME RECENT TRENDS IN GEOLOGY

GEOLOGY is one of the youngest sciences, having acquired the status of a science about 1800 by the publication of Playfair's interpretation of Hutton's classic and fundamental observations in England. It became firmly established in the family of natural sciences by William Smith's engineering work that led to stratigraphic studies and geologic mapping, and even more by Lyell's brilliant textbooks and articles in the 1830's and later years. About the same time, geologic articles and textbooks were appearing in the United States and state geological surveys were being organized. But a revealing light upon the infant science is cast by Merrill's observation that "at this date [1800 ca.] . . . none of the sciences were taught in the colleges and other institutions of learning in America or England. Indeed, the general trend of public opinion was decidedly against the study of geology. . . ." Landmarks of progress were established by the appointment, in 1802, of Benjamin Silliman at Yale and the founding, in 1818, of the American Journal of Science. Slightly more than a century thus measures the time of geology as a research science.

The youthful and virile science of geology made rapid progress during that century in interpreting man's environment and in discovering and utilizing geologic resources for the material welfare of society. It has developed into a mature science, the principles of which are of daily, widespread application in times of peace and of war in this age of the "Use of mineral resources." Geologic thought on fundamental principles has had various trends during this century of growth. A few of the 20th century trends are herewith interpreted.

The science of geology, like other sciences, has become more specialized during recent decades. Instead of geologic facts and principles being closely knit in a comprehensive unit, which any well-versed geologist could readily apprehend, field and laboratory research has resulted in the development of numerous branches as primary offshoots of the main trunk. Other sciences, particularly chemistry and physics, have nurtured some of the offspring until certain interrelations have become fixed. Some of the relatively new branches have grown into mature units; for example, the Geological Society of America at its 50th anniversary in 1938 recognized eight well-established major divisions of geology, which are subdivisible into twenty-five sections. In harmony with this decided trend toward specialization, the Geological Society and the American Association for the Advancement of Science have assisted the founding of several specialistic professional societies in the realm of the parent science of geology.

Pure research in geology and its economic applications have become more closely related during the 20th century. This trend no doubt will be accelerated by the urgent wartime need of the services of geologists and mining engineers to discover and develop adequate supplies of strategic minerals to win the war and mature the peace. Field work on all the continents and intensive research in industrial and university laboratories will support this trend. Pure research in most fields of geology may have slight opportunity to be cloistered in the post-war epoch of international industrial development.

A significant trend in economic geology has been the increased emphasis placed upon the diversity of local geologic environments in which recoverable quantities of petroleum may have accumulated. The need of extensive and intensive field exploration and laboratory research has been sharply accentuated by the depletion of our known petroleum reserves by the insatiable demands of this war. Full-scale post-war industrial activity and transportation will also require very large amounts of petroleum. Many types of "pure" research have in the last quarter century been skillfully applied to the solution of the general problem of increasing production from known fields and of discovering new fields.

Geophysics, the application of physics to the solution of geologic problems, has had a large part in some of the field programs since the first world war. The fundamental principles of sedimentation, once largely of academic interest only, have been more rigorously and widely applied. The study of

micro-faunas, also formerly of interest chiefly to paleontologists and biologists, has become an indispensable handmaiden of the geologist exploring for petroleum. More attention has recently been given to all the factors in the regional geologic history of a prospective petroleum district rather than to one or a few factors.

The sudden demands of the rapidly expanding armed forces and huge industrial plants throughout the nation for large quantities of ground water have focussed attention upon the fact that this indispensable, familiar geologic resource is locally limited in distribution and amount and that in many areas geologic principles and techniques must be applied in order to obtain adequate supplies. In consequence of such recent developments, ground water is becoming more and more recognized as being in the realm of economic geology. In passing, it appears strange that it has taken such a long time to classify ground water with other fluids in the rocks, to the acquisition of which geologic principles and techniques have been applied almost from the first industrial production.

Geologic field investigations and laboratory studies, made during the 20th century, of the fundamental constitution of coal have paved the way for a forthcoming technologic development of great industrial importance and individual interest; namely, the production of petroleum derivatives by the hydrogenation of coal. Synthetic gasoline is destined sometime, possibly within this generation, to take a strategic part in our national economy. Geologic and other scientific studies of vast deposits of "oil shale" also will have an important part in that forthcoming industrial drama.

Clay, long considered chiefly as the product of certain geologic processes and as an essential raw material in the ceramic industries, has become in the last decade or two the object of more critical geologic analysis. Not only are the results of industrial value, but the precise, quantitative studies have contributed to the solution of purely scientific problems in the realm of geology. The value of these studies in the solution of the manifold problems involved in a thorough study of our most basic geologic resource—the soil—has only recently become widely recognized. The new science of soil geology is developing in our midst.

Other mineral resources are being given precise study as never before. Limestone, for example, is no longer just a common rock. The chemical composition and physical constitution of many common earth materials and their relations to geologic environments are being determined on a quantitative rather than a qualitative basis. Exactitude in geologic research is supplanting, so far as possible, reconnaissance generalization.

Alongside the specialization of geology in recent decades and the development of more exact methods of field and laboratory research, another significant trend has been developing. In the early days of geology, the educated public had little difficulty in keeping informed about the significant discoveries and even of the development of some of the principal arguments. With the increasing specialization of the science, the public has wholly lost touch with many of its significant and socially important aspects. It may be more accurate to say that geologists have lost touch with the public. A significant sign of the times is that numerous geologists have become aware of the widespread lack of knowledge by the educated public as to what geology is and what it is good for. Thus have developed more and more attempts to interpret the findings of geologic research in terms that the educated public can understand.

ARTHUR BEVAN

# BOOK REVIEWS

## MATERNAL OVERPROTECTION*

THE twenty case studies in maternal overprotection presented in this book comprise the residual distillate of 2000 case records or 200,000 hours of case contacts accomplished at the former Institute for Child Guidance, New York City. Maternal overprotection is tentatively defined as ". . . a type of neurosis, in which especially processes of guilt result in exaggerated maternal care." The criterion of "pure" overprotection which determined selection of these cases is defined as ". . . exaggerated maternal love . . . overprotection which is not determined primarily by neurosis." This criterion was satisfied when the following characteristic relationships between mother and child prevailed: excessive contact; infantilization; prevention of independent behavior; and lack or excess of maternal control. These mothers, according to the findings of psychiatrists and social workers who participated in the study, manifested a strong "maternal drive." They were "naturally maternal" women whose maternal behavior had been intensified by psychic and cultural factors.

The life histories of the mothers revealed a deeply frustrated craving for love in childhood, anxieties during the period of anticipation, including in many cases a prolonged fear of sterility, and extra hazards concerning the child's health in infancy. Sexual incompatibility predominated in these marriages.

Direct psychotherapy with overprotected children in this study failed completely. As the author points out, "To expect a boy to overcome his mother's overprotection and modify behavior highly satisfying to him was certainly expecting too much." This observation should prove useful to many clinicians and social workers who adhere to the grim do-or-die philosophy in their contacts, especially in view of the unavoidable ego involvement which relationship therapy entails. This simple statement cuts many a Gordian knot of therapeutic failure in the clinic.

* *Maternal Overprotection.* David M. Levy. 417 pp. Sept., 1943. $4.50. Columbia University Press.

The book fairly bristles with exceedingly valuable clinical insights into the dynamics of overprotection and its treatment. For example, it was found that the attitudes of the mothers underwent little change despite the evidence of partially modified overt behavior. These fundamentally aggressive women really wanted help in re-establishing the mother-infant relationship and resented the clinic's attempt to lead the child into maturity.

The most successful techniques consisted of direct environmental change (camps) and specific advice combined with actual demonstration in the home. A follow-up survey of cases one or two years subsequent to therapy revealed that more than half of the children were partially or successfully adjusted. A later follow-up of nineteen cases into late adolescence or adult life indicated that more than sixty percent of this group were "partially adjusted." Whether the term "adjustment" is applicable in these cases is a debatable point. These follow-up studies highlight the perseverating effects of the silver-cord relationship.

Dr. Levy has made an important contribution by so lucidly delineating the dimensions of maternal overprotection and offering an operational blueprint of its ramified structure. The pitfalls and shortcomings of psychiatric treatment are candidly portrayed and should be of great value to young psychiatrists and psychiatric social workers who deal with this difficult problem. The multiplicity of etiological factors revealed in these studies should prove invaluable in orientating the accumulation of case history material in situations of this type. Research workers will find many challenges throughout the book.

The emphasis upon psychoanalytic rubrics might be deplored somewhat, as for example, such a statement as ". . . atonement in the form of good scholarship for the guilt of incestuous attachment." One wishes that other findings on overprotected boys, such as interest patterns, personality schedule, and Rorschach results, and other psychological and psychometric data could have been in-

cluded. The reader will also note considerable repetition of the case history material. Regardless of these faults, if faults they be, this book may be regarded as definitive in its field.

FRED BROWN

### LIBERAL EDUCATION RE-EXAMINED*

BECAUSE the American Council of Learned Societies "has become increasingly aware of various forces in American culture, and trends in American education, which threaten the very basis of all scholarship," a committee was appointed to prepare this volume. Previous to the appointment of the committee in 1940, a symposium was held in 1938 in which there were participants from such important organizations as the Modern Language Association of America, The National Federation of Modern Foreign Language Teachers, The Classical Association of the Middle West and South, and the American Philological Association. That symposium produced the plan for a "thoroughgoing study of the place of the humanities in education," a plan which became the starting point for the committee's work.

The committee was instructed that its duties did not include a "defense of the humanities," but to "develop the full values of the contribution that the humanities must make to education and to life." And the committee in commenting (Preface) on its finished work said that its task had not been "to be primarily fact finding or statistical," but "to formulate basic cultural ideals and educational objectives, . . . to define a common cultural and educational goal, not to specify in detail the means whereby this goal may gradually be approached." Instead of outlining subjects, types of procedures, or integrated relations with other divisions of human records and achievements, by means of which the humanities may produce the desired results, the committee asks that "educational institutions throughout the country will attempt, on their own initiative and responsibility, to actualize the ideals here envisaged."

Thus it might appear that the committee almost absolves itself from specifics, and uses an argumentative procedure which for more than fifty years has been a common method of dealing with the whole difficult problem. The fact that all the members of the committee and all the sponsoring organizations are directly concerned with the humanities might produce an expectancy that a reader of the book would meet abundant arguments for a very large place for humanities in general education. Such abundant arguments do appear; but concerning the large claims to which most humanists agree, it is stated that the members of the committee are not in full agreement; and of the American Council of Learned Societies, it is stated that "the scholars constituting this body were themselves in sharp disagreement on many crucial issues." Thus on an argumentative basis it seems that those who have spoken are not in full harmony. Possibly a fact finding basis might have produced a better foundation for unification in conclusions. The difficulty would have been in disclosing, analyzing, and synthesizing abundant facts to support what may have been predetermined contentions. By saying this, the reviewer does not mean to say that the argumentative conclusions are wrong. They are not proved by evidences of the objective sort which would be expected by other competent students of the same questions. Therefore, the conclusions are still within the domain of opinion, even though eminent and often convincing opinion.

A valuable point is made when referring to the cumulative nature of thinking about education. It is a mistake to assume that such thinking must be characterized either by the "horse and buggy" period or by the period of the stratosphere airplane. Rather it must be recognized that much thinking preceded "horse and buggy days" and there will be much to follow "stratosphere days." Even more significant is it that all along between such periods constructive consideration of education proceeded. The "fear that present trends have threatened the foundations of a humane as against a purely scientific education" is a fear that has grown steadily for many decades. Entrenched linguistics and other humanities felt the

* *Liberal Education Re-Examined.* T. H. Greene, Fries, Wriston, and Dighton. xiv + 134 pp. 1943. $1.50. Harper & Bros.

growing impact of fact-finding sciences. The human betterments produced through science and the opportunities for vocational, as well as scholastic careers in science, shifted emphasis upon educational values. Undoubtedly, human desire for a livelihood as well as a life (the unctuous term "the good life" is frequently used), helped to shift educational emphasis from the humanities toward the sciences.

It is sometimes incorrectly implied by the writers that most of science deals with practicalities. It would be difficult, however, to arouse much public interest in adverse criticism of science because of its tremendous practical benefits. The book fails to note that point. Furthermore, it is idle talk to claim that persons educated through scientific pursuits are really less educated than are those who devote their abilities to the humanities. The sciences are not necessarily inhumanistic or uncultural, nor are the classics, languages, and literatures necessarily humanistic and cultural. It depends upon how they are approached, studied, used, and incorporated into one's living. The statement is made that "only liberally minded teachers and students can achieve a liberal education; for such education depends essentially upon contact of mind with mind in dealing with significant ideas." Does that mean that one must be liberally minded before he may achieve liberal mindedness?

Then, it is urged that the very long period during which certain subjects "have been reviewed, criticized, sharpened, and made more appealing and effective, . . . gives to these studies, which are the substance of the liberal arts, a unique quality which other disciplines can acquire only after like periods of developing maturity. . . . The liberal quality of education was bound to suffer by having the darling of the new education dominate what was left of the old. Science was too triumphant to be denounced." The authors then cite and deprecate the efforts of liberal arts subjects to become "scientific" by application of so-called scientific methods within their own fields. It seems clear that such efforts have not proved satisfactory.

This reviewer has constantly watched throughout the book for clear statements of what liberal education is. Several part definitions are given. "Liberal education seeks to bring into life greater refinement and greater intensity—to make it more sensitive, to make it more alive. . . . It is 'preparation' for life only in the sense that its vital influence is continuous and leads ever on from one experience to others which are even richer." In the chapter dealing with "The Ideal Objectives of a Democracy," when discussing what is best for development of political responsibilities, it is stated that "the most effective type of preparation both for citizenship and for the good life is a liberal education. Such education is, as we shall see, essentially cultural in content and reflective in approach." It is further asserted that a liberal education is "informative," "disciplinary," "liberative," and "moral," and is "the only effective education for the good life of the individual." "Education for citizenship, accordingly, is identical with education for the good life. A liberal education is the only education for either objective. . . . It alone can give men the factual knowledge, the sense of basic values, the perspective and critical attitude, requisite to responsible citizenship." Many other such quotations might be made. All of them are similarly assertive or argumentative and unsupported by tested evidences.

More than one-fourth of the book is devoted to the chapter on "Content of a Liberal Education," of which a little more than two pages suffice for "The Natural Sciences." Even so, the following closing sentence of that section is highly significant: "Whoever believes that it is more honest to face facts than to ignore them, and to interpret facts in a rational manner rather than an irrational manner, will value particularly this general contribution of science to man's intellectual and spiritual integrity." As expected, the really essential liberal studies, the languages, ancient and modern, the arts, literature, history, and philosophy are given the "central role" in a liberal education. And the arguments, excellently stated, include those recorded for many decades plus some that are ingeniously new. We believe many of them. In fact, most people want the cultural heritage of the humanities,

though there seems to be no good reason as to why these cultural values may not be developed along with the values of other types of liberal education than those advocated in this book.

Under "Various Academic Levels" the authors discuss, severely criticize, and make recommendations dealing with teaching and what is taught in all levels of education. These discussions and recommendations, most of which are interesting and sound, are strikingly more definite concerning elementary and secondary education in which none of the authors is working, than are those concerning collegiate and graduate education with which the authors are professionally closely associated.

OTIS W. CALDWELL

**MAN'S FOOD: IT'S RHYME OR REASON***

THE main (and new) character of this volume on food is given by the author in the first paragraph of his introduction: "This volume differs from other books on food in that it deals as much with man as it does with food. Its main concern is with man's attitude towards food throughout history, before and during the evolution of the science of nutrition." While the book is written primarily for the lay public, the story of man's aberrations in regard to many good and wholesome natural foods, such as eggs, fish, meat, and milk, constitutes *must reading* even for experts on human nutrition, as this story helps to explain some of the current dietary aberrations in our country today, and familiarity with this story will be helpful to us all, and especially to those fellow citizens entrusted with the important duty of aiding a starving world, when the current war violence has subsided.

We may assume that all wild animals (including very early man) were, at least from time to time, forced to eat every available edible article of plant and animal sources. And it is a fact that all forms of animal and plant life contain elements useful as human food, even such rarely used plant products as grasses, leaves, and the fresh bark of trees. Very few plant and animal tissues anywhere in the world contain poisonous elements when used as human food. This being the case, the various taboos (religious, social, and sexual) against good foods developed by so many peoples, are in reality not primitive. For we cannot assume that their primary origin was special food idiosyncrasies (food anaphylaxis); as this appears in individuals, not in the tribe or group as a whole. It is not surprising, therefore, that some of these food taboos are current, even among relatively educated people today, even though the very origin of the food taboos presupposes two conditions: (a) almost complete ignorance as to the nature and functions of foods, and (b) plenty of foods not under taboo. Workers in nutrition would have found the human aspect of this volume more valuable if the author had cited at least some of his authorities. There is no literature reference in any of the eighteen chapters.

Most of the specific food data and dietary recommendations in the several chapters are not only factual but clearly and interestingly presented for the lay reader. Wholly erroneous assertions, like the following, are exceptional: "The value of fruits and vegetables lies wholly in their possession of small quantities of vitamin C" (p. 37). But readers might ask the author for the evidence for the claim (p. 201) "deficiency in vitamins is one of the causes for high infant mortality" (in U. S. A., presumably).

There are chapters on "Table Manners," "Food and Morale," and a "Postscript on Freedom from Want of Food." Considering the times and the author's connections, the reader should not be surprised to encounter some rather wishful thinking, if not *lapsus menti,* in some of these chapters. Thus the author says (p. 58) that our current flour and bread enrichment practices "have solved the entire problem (of denaturing our food grains) pleasantly and effectively." The solution may be pleasant to some, but is it effective for all, and for all times? Is it as effective as whole wheat, taboos or no taboos? On page 29 we read: "The percentage of malnutrition (in U. S. A.) is much smaller than the mythical, and by now classical, third." This does not seem to square with

* *Man's Food: Its Rhyme or Reason.* Mark Graubard. x + 213 pp. Nov., 1943. $2.50 ($2.00 to members of the American Association for the Advancement of Science, if ordered through this Association). Macmillan.

his statement on page 201: "surveys show that the majority of our (U. S. A.) population is malnourished." Do we have to be convinced and convicted of total depravity before we accept salvation?

A. J. Carlson

## FOOD IN WAR AND PEACE

When a subject becomes so popular as to figure almost daily on the front and editorial pages of newspapers, over the radio, in magazines, and in the newsreels—then that subject stands a pretty good chance of being confounded and misunderstood. When, in addition, the subject happens to be food which is linked to science, nutrition education as well as war and peace, then the misconceptions, false warnings, fears, and useless oratory bubbling around it may well reach extraordinary proportions. It is for these reasons that the American people are fortunate in having had a 1943 Christmas gift in the form of *Food "Crisis"*[1] by Roy F. Hendrickson and *Food Enough*[2] by John D. Black.

Mr. Hendrickson's book is a model of clear exposition and complete coverage. It is intended for the layman and its style, its contents, and organization are so expertly directed toward that objective that the result is a most lucid account of the food situation in the United States and its effect upon the rest of the world. It reads like a novel and is written in a concise but mellow style without embellishment but with an inherent ease of flow which carries the reader along thoroughly interested, thoroughly pleased because he is really learning point by point the elements of a complicated but fascinatingly elucidated problem.

What is most gratifying is that the subject is handled with reserve, dignity, and unique impartiality, which are particularly striking in view of Mr. Hendrickson's responsibility as director of the Food Distribution Administration. There is no condescension in tone often displayed by so many who write for the laymen, and there is no trace of seeking to defend policies simply because the author happened to be involved in their adoption. The book is a classic achievement in adult education which analyzes the food problem and its numerous aspects frankly and honestly with authoritative knowledge and impelling logic.

After presenting a survey of the present food situation under the heading, "America Wakes Up—To Face a Food Problem," the author considers the war tasks at home in the matter of adequate food for the civilian population, the needs of the military and the Allies, the problems of Lend-Lease and of feeding occupied lands. He next considers the questions of rationing, prices, subsidies, and the problems confronting the farmer on the production front. Especially informative are the chapters dealing with the way Britain is solving her food problem and how her methods compare with our own. The reader is also offered a thorough picture of the role of food in World War I and the present food situation in Germany. The concluding chapters deal with tasks still requiring careful thought regarding post-war possibilities on the food front. One almost feels confident that if the professional Cassandras and other vociferous critics could only take time off to read this volume our road to victory would be far smoother than it is with their present clamor. The average citizen stands to learn much from reading this book. He will learn how difficult the problem has been, how much there was to do, how it is being handled now and how easy it is to be an arm-chair food philosopher offering glib solutions for all domestic and foreign difficulties. But the problems of feeding our population, our armed forces, and aiding our allies are in reality quite tough. Yet these jobs have been done fairly well.

Professor Black's book runs much along the same lines as Mr. Hendrickson's. It is briefer and amply furnished with charts and tables. It too is an excellent account of the food situation and the charts and tables it offers are so clear that their aid in summarizing complex data is apparent to anyone. Professor Black's outline follows more or less the same sequence as Mr. Hendrickson's since both are motivated by the logic of the story they have to tell. The approaches taken by each are sufficiently different to

[1] *Food "Crisis."* Roy F. Hendrickson. xii + 274 pp. 1943. $2.50. Doubleday, Doran.

[2] *Food Enough.* John D. Black. 269 pp. 1943. $2.50. The Jaques Cattell Press.

make both books prescribed reading for anyone concerned in any way with food, its production, distribution, or use.

Besides its wealth of information, clarity of style, and plethora of data, Professor Black's book is of special interest in that it comes from the pen of one of the ablest students of food economics not in the employment of the government. His judgment is consistently fair and his points of criticism are certainly to be taken seriously. His general conclusions that the food situation has been handled with competence and as well as could be expected under the circumstances, should be encouraging to the public. His critical comments should be found stimulating especially by those who are responsible for national strategy on the food front.

One positive point may be made after reading these two enjoyable and instructive volumes. There can no longer be any good excuse for nonsense on the subject of food sown broadcast or otherwise dispensed by common people, their representatives, professional authors, radio commentators, or editorial writers. The facts are available and just as the public reads war books it should read these two works which deal with the basic war problem of food. Moreover, while intimate knowledge of the fighting in Italy or the Solomons does not in all likelihood make a better citizen or a more valuable armchair strategist, knowledge of what is involved in solving our food problems is a contribution to good citizenship. Victory on the food front can be achieved only by the wholehearted cooperation of farmer, manufacturer, and consumer. It is the duty of each citizen to know what is involved in solving the various aspects of the food problem. After reading these books, the average citizen is really put in the position of an intelligent democratic participant on the home front.

MARK GRAUBARD

## SHRUBS OF MICHIGAN*

THE Cranbrook Institute of Science and Mr. Billington should be commended for this excellent book presenting in such precise and readable form the shrubs of Michigan. In this work 161 species of shrubs, all that are known to occur in Michigan, are included, each represented by drawings of fruit, leaves, flowers, and inflorescence, and accompanied by a small map of Michigan outlining the counties and indicating actual records.

The drawings have been very simply, neatly, and accurately executed, and are indispensable in a work of this kind designed especially for the nature lover and those who cannot be professional botanists. A color frontispiece, depicting autumnal coloration transforming a zone of shrubs to crimson against a background of dark green coniferous trees, adds an attractive artistic feature.

The keys to the genera and those to the species in the text are clear and workable, more especially because eighty-eight line drawings in a pictorial glossary illustrate many of the descriptive botanical terms with which the amateur might not be familiar.

The reviewer feels that this book will be of great value to all nature lovers and amateur botanists who wish to familiarize themselves with the native shrubs of their state. There is a need for more books of this sort, for they have great educational value for thousands of persons who have not had the training nor the inclination to become professional botanists or taxonomists. Such books, with the subject matter presented attractively, clearly, and accurately, are of far greater usefulness to the average person than technical monographs or manuals covering large areas of the country. *Shrubs of Michigan* by Mr. Billington is in this class.

H. A. ALLARD

* *Shrubs of Michigan.* Cecil Billington. Bulletin No. 20. Illustrated. 249 pp. Dec., 1943. $2.50. Cranbrook Institute of Science.

# COMMENTS AND CRITICISMS

### Apology

We shall not wait for a reader to ask us who wrote the article on the work of Dr. Frank Schlesinger, which was published under the title, "Explorer of Celestial Spaces" in the March issue of *The Scientific Monthly,* pp. 240–242. This article was an abridged version of an address by Dr. Henry Norris Russell, which he delivered at the exercises in memory of Dr. Schlesinger in Strathcona Hall, Yale University, November 19, 1943. We regret the inadvertent omission of Dr. Russell's name at the end of his article and offer our apologies to him and to our readers.—Eds.

### War Effort

I have unfortunately misplaced the letter you sent me and, by golly, I can't remember your name. I think it is Carpenter, but I am not sure. At all events, the reproof in your letter was merited in part. I haven't been asleep at the switch, but I found that I wasn't as good a listening post as I thought. In addition to this, much of the work being done by anthropologists today is in connection with the war effort and there is a certain amount of hush-hush about it. At all events I have written an item for "Science on the March" which now has to go through the red tape of army clearance. If you will sit tight for all of this rigamarole, you should have something from me one of these days. I saw Dr. Moulton last Sunday and explained to him that I have darn near bitten off more than I can chew. However, I will keep plugging and will do my best.—Wilton M. Krogman.

Our contributing editors *are* doing their best to supply timely and illuminating articles for "Science on the March." While their articles are germinating or being cleared, "Carpenter" has been sawing wood to fill space. He regrets the necessity of giving our readers an overdose of insecticides and hopes that his specialty will not obtrude again. This note is written to invite contributions for "Science on the March" from our readers.—Eds.

### Diethylstilbestrol

The objective of your new section "Science on the March" is very much worthwhile. Scientific progress is rapid on so many fronts that it is extremely difficult for one to keep his head above water even in his special field.

However, such a section, to achieve its purpose, must be edited with extreme care. In the January issue under the heading "synthetic sex hormones" I find a confusion between "stilbestrol" and diethylstilbestrol (to use the American spelling). This confusion is probably a reflection of the fact that in the U.S.A. "stilbestrol" has often been used where "diethylstilbestrol" was meant. The Council on Pharmacy and Chemistry of the American Medical Association has not always agreed with the Food and Drug Administration in this regard.

In his original publication, Dodds reported the preparation and testing of several derivatives of stilbene (diphenylethylene). Among these were 4,4′-stilbenediol and α,β-diethyl-4,4′-stilbenediol. The latter compound has achieved considerable clinical use both under the name "diethylstilbestrol" and "stilbestrol." The former name was first assigned as the "common name" by the Food and Drug Administration. The Council sanctioned the latter.—E. Leon Foreman.

At the bottom of the first column on page 80 of the January, 1944, issue of *The Scientific Monthly* the editor innocently published: "A derivative of stilboestrol, known as diethylstilboestrol. . . ." Dr. Foreman points out above that these two common names are synonymous, both referring to the chemical compound α, β-diethyl-4,4′-stilbenediol. The Food and Drug Administration now requires the commercial product to be labeled under the name diethylstilbestrol, which may be regarded as the name generally accepted in the United States for this synthetic sex hormone. —Eds.

### Interpretation

I am wondering whether the exclamation "oh" on page 164 of the February issue of *The Scientific Monthly* was occasioned by the second sentence of the item which contains two well-defined grammatical errors.—Curvin H. Gingrich.

### An Astronomer's View

Dr. G. A. Lundberg's statement concerning postwar efforts ("Scientists in War Time," *The Scientific Monthly,* February 1944, p. 89) that, "No matter who wins, appeasement and compromise will occur because there is, practically speaking, no alternative," is surprising. If he means that in connection with the peace settlement, appeasement and compromise will not be wholly absent, few will disagree. But apparently he thinks that the peace terms must consist wholly or essentially of appeasement and compromise, for the next sentence reads, "The only subjects for profitable discussion are the details of the appeasement and compromise."

The context supplies one or two arguments for this disheartening conclusion. One is that after

World War I "the machinery of appeasement and compromise was set in motion." But does this fact prove that after World War II no other machinery can possibly be used? Dr. Lundberg's argument is marred by a misstatement. "No one could have desired a more complete military victory than that achieved by the Allies in the first World War." It is reported that General Pershing desired a more complete victory.

Dr. Lundberg indicates that annihilation of the defeated nations would be an oversimplified and unavailable solution. His failure to discuss a third possibility, namely, that after victory the Allied Nations might force Germany and Japan to follow a prescribed course is puzzling; it seems to me to leave his treatment narrow and unsatisfactory.

In the absence of an impartial judge, does any moral principle of symmetry require that after the war we refrain from enforcing our ideas just because we think we would dislike what Germany would do to us had she been the victor? The vigilante type of justice may not be ideal but it is probably better than none at all. The Golden Rule is not available for the protection of a nation that violates it.—Paul W. Merrill.

### From an Editor

Since you kindly invited my comments on the January issue I should like to make a few remarks. The choice of original articles seems to me almost perfect; all of them are on timely and interesting subjects. I think, too, that the section on "Meet the Authors" is a great addition. It seems, however, that comparatively few qualified workers in science possess much ability to write clearly for the general public; the conclusion I think is that more work should be expended on editing papers of this kind than almost any other type of published material.

I think it might be advantageous to consider setting up a small department for publication of correspondence. It is my belief that when suitably controlled, correspondence can form an exceptionally interesting part of a magazine or newspaper. The section on Science on the March is excellent and might I think be expanded to include items of spot news in science and, perhaps, even some personal news.—Edwin P. Jordan.

### To J. O. Perrine

I cannot refrain from sending you my thanks for the most elucidating exposition of electromagnetic waves I have yet seen, and which I have just finished reading the second time.

I have long had a hobby in physics and enjoy the study greatly when as in your case the subjects are presented from "the bottom up" instead of from "the top down." I have been reading *The Scientific Monthly* for years and shall always preserve the January, 1944, issue.—David J. Lewis.

### To the New Editor

Methinks I see Frank in his new office chair,
A-wrinkling his eyebrows and pulling his hair,
Redacting like mad on some horrible script
And thinking how much of it ought to be skipped.

Correcting, amending, adjusting and then,
By aid of his much over-worked office pen,
Removing a colon, inserting a dash,
Re-writing a sentence that's too much like hash.

At home and in bed, when he's trying to sleep,
He'll have to count commas instead of the sheep.
At last when he's finally slumbering there,
The marks diacritic will get in his hair.

Inverted construction will give him a pain,
The wrong use of words will confuse his tired brain,
While nightmares composed of the bum paragraphs
Cavort on his tummy with devilish laughs.

There's no easy chair in the editor's suite
And you can demolish your pants in the seat
As fast as you could if you still were to be
Assigned to a "chair" in the old B. & Z.
—Raymond C. Osburn.

# THE SCIENTIFIC MONTHLY

MAY, 1944


## PLOWSHARES INTO SWORDS

By E. C. AUCHTER and GOVE HAMBIDGE

SIGNIFICANTLY, *ara* is the Latin word for *the plow,* root of the Latin verb meaning *to plow* (*arare*) and of the English word *arable.* By a happy accident, the initials ARA in our alphabetized Government agencies stand for the Agricultural Research Administration. The plow, the man behind the plow, the draft animal or tractor that draws the plow, the crops that follow the plow—all these are part of the complex of associations clustering around the name ARA. It would be hard to find a name that better symbolizes things agricultural.

Late in 1941, in the first of the wartime reorganizations of the U. S. Department of Agriculture, ARA was created by grouping most of the research agencies into one unit, with an administrative head responsible for planning, coordinating, and directing the work and focusing it on the solution of war problems. Seven agencies are included in this unit: Agricultural and Industrial Chemistry; Animal Industry; Dairy Industry; Entomology and Plant Quarantine; Experiment Stations; Human Nutrition and Home Economics; and Plant Industry, Soils, and Agricultural Engineering. It also has charge of the Beltsville Research Center. The Center consists of farms, greenhouses, and laboratories handy to Washington where scores of research programs are carried on, primarily by these agencies but also by some others in the Department.

Thus ARA pulls together and integrates most of the research in the natural sciences carried on by the Department; and this represents a very wide range. A map in the central office shows that geographically the field stations and laboratories of ARA agencies—including four big regional laboratories devoted to industrial uses of farm products and nine Bankhead-Jones laboratories carrying on rather fundamental research—are sprinkled over the length and breadth of the country. In addition, research projects in cooperation with the Federal Government are conducted by State experiment stations in every State through ARA's Office of Experiment Stations.

This varied and widespread network of research is not new, nor for the most part are the agencies conducting it; the Department of Agriculture has long been known as one of the leading organizations in research in the world. What is new is the closer coordination of all research, made possible by unified planning and direction; the stimulus and drive that result from the challenge of wartime; and a large number of projects arising directly from the necessities of war.

### WANTED—MORE OF EVERYTHING

At the beginning of the war the research work of the ARA agencies was carefully reviewed and much of it was modified, within the framework of legislative authorization, to bear as directly as possible on war needs. In this process, long-time basic research, on which much money had been spent, was not abandoned but set aside; valuable material, such as breeding stocks and experimental orchards, has been preserved and maintained, so that at the end of the war the work can be picked up again where it was interrupted.

The nature and objectives of agricultural research during the war are largely determined by the fact that for one reason or another war creates shortages of practically

everything: of materials, of men, of space, of time itself. Some of the resulting problems can be met by applying the knowledge accumulated through many years of research in the past—knowledge that has proved to be a war chest of immense value. Other problems must be met by new research, and these the agricultural scientists are attacking successfully.

The main types of problems ARA is called upon to solve at this time are these:

*Bigger and better crops.* There will never be too much of the essential agricultural products to meet the combined needs of the home front and battle front during the war, however generous the supplies may be in relation to peacetime demands. Science is asked to find ways to increase production.

*Protection of crops and livestock.* Waste is inexcusable in war (except the astronomical waste represented by war itself). Research must redouble its efforts to protect crops and livestock from their natural enemies.

*Shortages of feeds and foods.* Good management of the country's supplies of livestock feeds and human foods in wartime calls for a background of thorough scientific knowledge. At stake are the efficiency and health of the Nation, including its armed forces.

*Shortages of other agricultural products.* Many essential products are either no longer available because supplies are cut off by war, or scarce because they are diverted to direct war uses. We must learn to grow things we have not grown before—or find suitable substitutes.

*Help for consumers at home.* In scores of ways, consumers need help in solving wartime problems vital to their well-being. Much of this help must be in the form of information that is impartial, accurate, and backed by adequate research.

*Demands of the armed services and other agencies.* Agricultural research is called on to help in solving many special problems of the armed services and other war agencies.

Without writing at great length, it would be impossible to give a complete picture of all the agricultural research that has been done or is being done under these general headings. Out of the mass, only a few examples can be given as important illustrations.

## Bigger and Better Crops

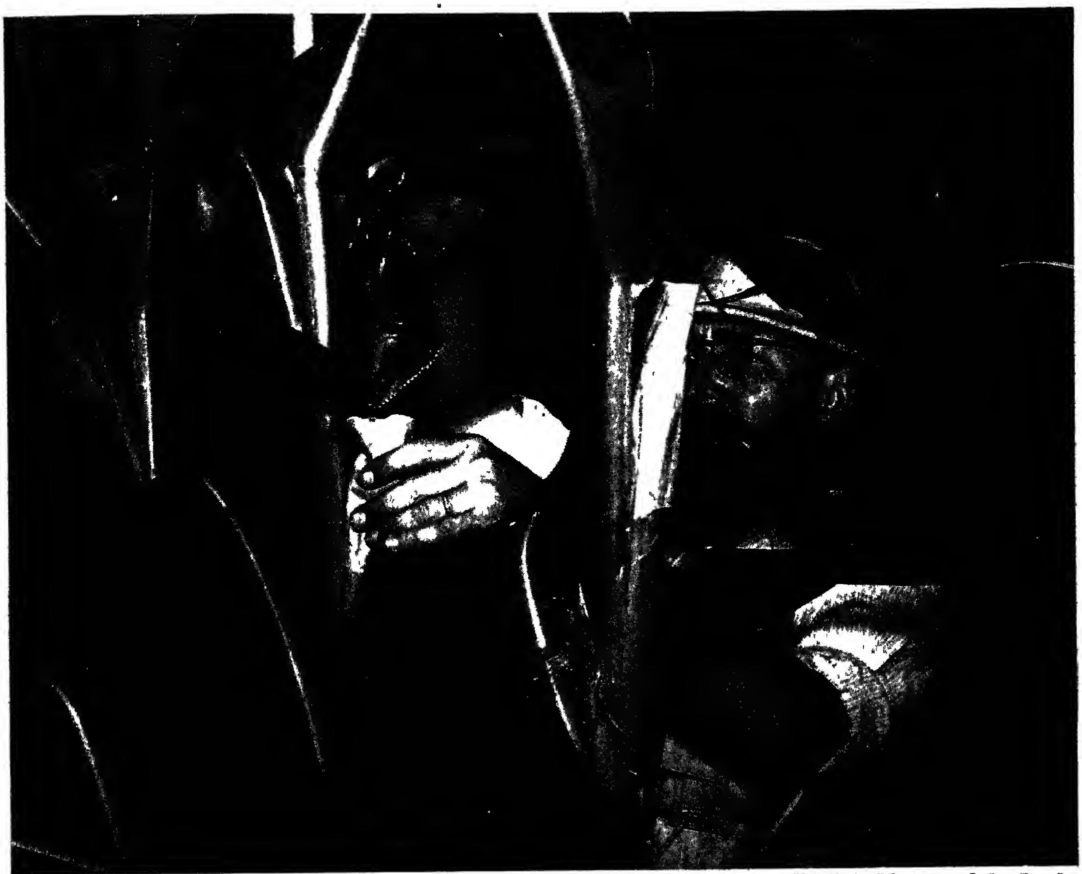
*How the Plant Breeder Steps Up Pork Production* One of the most striking achievements of modern plant breeding is hybrid corn. Not a war development, it nevertheless came precisely in time, like many another product of agricultural research in recent years, to have a telling effect on our wartime food supply.

In 1933 hybrid corn was making a modest debut on one-tenth of one percent (143,000 acres) of the corn acreage in the United States. By 1938 it occupied about 15 percent. Last year, 1943, it took about 52 percent—some 15 million acres more than in 1941. In the heart of the corn belt, Iowa, 98 to 100 percent of the corn acreage in every county was planted to hybrid seed last year. The same was true in two-thirds of the counties in Illinois, and half the counties in Indiana.

From the standpoint of war production, the significance of this amazingly rapid spread is that hybrid corn consistently outyields open-pollinated varieties by 20 percent. Planting hybrid corn, then, means increasing production by one-fifth without using more acres or manpower. One statistically minded plant breeder estimates that in 1942 about 630,000,000 more bushels of corn were produced through the use of hybrid varieties than would have been possible without them, and that this amount of corn would make 6,900,000,000 pounds of pork. Thus a large share of our wartime pork production can be attributed to the work of plant breeders. Hybrid corn is only one of many contributions plant breeders have recently made to bigger and better crops that fit war needs.

*No More Cows But Much More Milk.* Dairying offers an example of the enormous potential increases in production, not by any means fully realized, that can be brought about by research.

There are some 26 million dairy cows in the United States. The average production of these cows is around 4,700 pounds of milk a year; it has been rising steadily for many years through the use of more scientific prac-



*U.S D.A. Photograph by Purdy*

POLLINATING CORN ARTIFICIALLY FOR PRODUCTION OF A HYBRID

HYBRID CORN, DEVELOPED AS A RESULT OF RESEARCHES IN GENETICS, EXEMPLIFIES THE INFLUENCE OF THEORETICAL SCIENTIFIC RESEARCH IN REVOLUTIONIZING PRACTICES FOR PRODUCTION OF AGRICULTURAL CROPS.

tices. But scattered throughout the country are Dairy Herd Improvement Associations, controlling some 800,000 cows, the average production of which is over 8,000 pounds of milk a year. This figure is not a record but a practical achievement by practical farmers; the present world's record production is 41,943 pounds, and in the experimental herd of the U. S. Department of Agriculture at Beltsville, Maryland, the average production of cows on test is about 16,000 pounds.

DHIA herds, of course, are better fed and better managed than average cows, but much of their superior producing ability is due to breeding. Dairy geneticists in the Department of Agriculture believe that a greatly widened and intensified breeding program would rapidly raise the production of dairy herds throughout the United States toward the DHIA level. The geneticists have elaborate figures to back up their opinion, including records, collected during the past six years, of thousands of bulls that have been proved to be capable of siring daughters that will produce more milk and butterfat than their dams. In most herds production fluctuates up and down from generation to generation because of the haphazard use of good and bad sires. The consistent use of proved sires, the geneticists believe, would steadily and surely raise production levels. Other things being equal, the average production of our herds might be almost doubled without adding a single cow to the dairy population. Any such achievement would require a large-scale program, including much greater use of artificial insemination. By this technique, the inheritance of a good bull can be spread over eight or ten times as many cows as by natural methods.

*U.S D A. Photograph by Peter Killian*

ADMINISTERING PHENOTHIAZINE TO REMOVE WORMS FROM A SHEEP

ZOOLOGISTS OF THE U. S. DEPARTMENT OF AGRICULTURE, WHO DISCOVERED THE VALUE OF THIS NEW DRUG AS LIVESTOCK MEDICINE, RECENTLY DEVELOPED A METHOD FOR ADMINISTERING IT IN THE ANIMAL'S SALT LICK.

Meanwhile, the dairy scientists are going ahead as extensively as facilities permit to spread the use of proved sires. The records show a steady rise in production where these sires are used.

### Protection Against Natural Enemies

In spite of everything that is done to combat diseases and insects, they continue to take a heavy toll among our crop plants and livestock. Each advance, however, means that the losses due to some disease or insect or parasite are reduced, even though they may not be completely eliminated.

Phenothiazine is one of the products that is turning out to be of great value in reducing losses—in this case, those caused by parasites in livestock, particularly sheep. It is a sulfur compound which turned up in the course of research begun as far back as 1928 in the effort of entomologists to find nonpoisonous insecticides for spraying fruit. Ten years later it was tested as a killer of internal parasites in animals, and it turned out to be the most useful weapon in the whole arsenal of anthelmintics. Thus it came along just in time to play a part in the war.

Most anthelmintics are highly selective; they kill one parasite or group of parasites in one kind of animal. Phenothiazine, on the other hand, can be used against several different parasites in several kinds of animals. It is not so potentially harmful as many other anthelmintics, some of which must be used with great care to avoid violent effects. Finally, it can be administered with more ease than many other anthelmintics. It need not necessarily be given as a drench or administered as a capsule but can be mixed with the feed, or, in the case of sheep, with the salt the animals habitually lick.

Sheep are among the most parasitized of

all classes of livestock, and by the same token parasites are the sheepman's worst problem. After licking salt containing 10 percent of phenothiazine for about a month, a sheep is relatively free of the worms that do the greatest harm Thriftier animals, more wool, more meat, and sounder intestines result from this treatment. The last point is peculiarly important in wartime. Sheep intestines are the source of the "catgut" used for sewing up wounds. Nodular worms ruin the intestines for this purpose by peppering them with small, gritty lumps.

Much progress has been made recently in combating some troublesome livestock diseases and in breeding disease-resistant plants Notable in the latter field is the Pan-American tomato (resistant to fusarium wilt), wilt-resistant strains of alfalfa, and rust-resistant oats.

### Shortages of Foods and Feeds

Fortunately, the period between the first and second world wars was extraordinarily rich in contributions to our knowledge of nutrition, so that we are able to meet the gigantic food problems of this war with a fund of scientific information never before available. To this knowledge, developed in the inter-war period, USDA nutritionists contributed a good deal, especially in techniques for measuring the nutritional quality of the diets of families and populations, and for translating such nutritive elements as proteins, minerals, and vitamins into practical food budgets usable by an individual or a family, or, on a larger scale, by the production planners. Hence these nutritionists are constantly called on for fundamental assistance in food planning during the war.

Some of their recent studies, for example, showed that during 1940, 1941, and 1942 the average civilian in the United States had a better diet, judged by content of calories, protein, fat, minerals, and vitamins, than during the pre-war years, 1935–39. During 1943, according to these analyses, the levels for proteins, minerals, and vitamins were about the same as in 1941 and 1942, except for thiamine, which was markedly higher. Thus, a scientific appraisal indicates that in spite of heavy war demands on our food supply, the over-all picture for civilians is not dark; in fact, some of the shifts in food habits necessitated by the war have improved our diets nutritionally. In particular, the average diet is richer in four important nutrients—calcium, niacin, thiamine, and riboflavin—than it was in the five pre-war years

Among the shifts necessitated by war is a lesser dependence on meat as a source of protein, partly because the armed services need large quantities of meat, partly because livestock necessarily compete to some extent with human beings for the existing food supply. In general, the poorer a country is, the less it can afford to feed and eat animals or animal products and the more it must depend on foods produced directly from the soil. Since war makes all countries relatively poorer, the trend during war, whether we like it or not, is inevitably toward a less varied diet, with greater dependence on plant products, particularly grains.

Along with proteins of animal products, the proteins of legumes and nuts are of the greatest nutritive value to human beings; and among these, the proteins of soybeans stand particularly high, probably, according to recent research, because they include sizable amounts of certain amino acids needed by the body and adequately supplied by animal proteins. When the supply of meat must be made to stretch, therefore, it is worth-while to have soybeans to fall back on. Fortunately, to meet the demand for oil during the war, this country has become the world's greatest producer of soybeans, as noted later in this article. Crushing these soybeans for oil leaves enormous quantities of press cake which can readily be converted into either livestock feed or human food. Last fall, large amounts of soya flour and grits appeared for the first time on the American market as human food. To most Americans these were new food products.

Preceding this development, ARA nutritionists made careful studies of the nutritive value of soybean flour and also of two other possible high-protein flours, made from peanuts and from cottonseed. All three gave remarkably good results as measured by their ability to promote growth in albino rats. The experiments showed also that the

proteins in these products admirably supplement those in wheat. In addition, soybeans are a good source of other nutrients.

Since most Americans will be unfamiliar with the use of soya flour and grits in cooking, recipes for a variety of dishes from soup to dessert were worked out and carefully tested by the home economists.

### Shortages of Other Agricultural Products

*Developing Natural Sources of Rubber.* For many years USDA plant explorers and plant breeders have done a certain amount of investigating and experimenting with rubber plants suitable for the Western Hemisphere and have emphasized the need for investigations on a larger scale. War events proved the wisdom of this pioneering work and brought an immediate amplification of it

The hevea tree is native to South America, but attempts to grow it there failed largely because of a devastating leaf disease. USDA scientists discovered resistant strains, which were subsequently propagated and selected for superior yield. Some of these strains furnished the nucleus for the present plantation rubber program, carried on under cooperative agreements with fifteen Latin-American republics. At sixteen field stations, superior planting material is propagated and distributed, demonstration plantings are used to teach growers modern methods, agronomic and pathological investigations are conducted, and enormous quantities of seed collected from wild trees in the Amazon region, often in nearly inaccessible areas, are tested for further improvement. At the Ford plantation in Brazil and elsewhere, work is carried on in the making of carefully controlled crosses between trees of Far Eastern parentage and native stock. During the past two years some 25 million seeds were planted in nurseries from Mexico to Brazil for seedlings on which to graft superior, high-yielding strains. A beginning has been made in the development of producing plantations. But hevea trees take at least six or seven years to come into commercial bearing; hence quicker sources of natural rubber are being fully investigated.

The Mexican shrub, guayule, is usually harvested in four or five years, but when grown under irrigation it can be harvested in two years if the need for rubber is great This plant has been studied to some extent by USDA scientists for two decades in connection with experimentation by a private company. Early in 1942 the Forest Service started large-scale experimental plantings, with ARA bureaus furnishing the research background and assistance. The work has involved studies to determine soil needs; pathological and entomological investigations; the development of suitable planting, cultivating, and seed- and plant-harvesting machinery; testing of strains with possible superior survival value in arid regions; and the development of efficient methods for extracting the rubber from the plant.

The list of plants that contain rubber in small or comparatively small quantities is considerable. Some give a harvest the first or second year, but each has its headaches in the form of poor yield or poor quality of rubber or difficulty in extracting the rubber. Several of the most promising, including goldenrod and kok-saghyz, have been under intensive study by ARA researchers.

In the case of most rubber-bearing plants, the problem involves a concerted attack by horticulturists, breeders, cytologists, pathologists, entomologists, soil scientists, chemists, engineers, and others.

*Synthetic Polymers from Agricultural Sources.* Meanwhile work has been pressed on the development of processes for making synthetic rubber and rubber substitutes from agricultural products. Information on two of these processes has been made public. One uses butylene glycol, produced from grain by fermentation, and the other fatty acids from oil-bearing seeds. Both processes were developed by the Northern Regional Research Laboratory.

The butylene glycol process is in effect something of a short-cut as compared with the production of rubber from alcohol as the basic material. In both cases, the basic material is converted into butadiene, from which Buna-type rubber is made by polymerization. Butylene glycol also has potential uses as an anti-freeze and in commercial solvents.

The oil process uses corn, soybeans, or

other products as source material and consists in polymerizing one of the fatty acids to produce a rubberlike substance. Other fractions of the oil are left as usable byproducts. The USDA product has been called Norepol (from NOrthern REgional POLymer), but commercial firms adapting the process have given their products trade names of their own. Several companies are now making the rubberlike polymers which have characteristics enabling them to replace rubber for a number of uses, including tubing, shoe heels, plumbing gaskets, waterproof fabrics, and adhesives

The butylene glycol and the Norepol projects illustrate the value of the pilot-plant method now being used extensively in ARA research. The perfecting of a process at the laboratory table tells little about its practical value; all kinds of difficulties, great and small, can develop in commercial production. To discover and eliminate them as quickly as possible, a large-scale laboratory simulating commercial conditions—in other words, a pilot plant—is invaluable. Pilot plants for a number of different kinds of processes are in operation at the four regional laboratories. In addition, close cooperative relations have been built up with industry. As soon as a new process or product has reached the point where it looks really promising, commercial producers are invited to cooperate in further research and development. This greatly widens the personnel and facilities that can be focused on the problem and its solution. It is not too much to say that in some recent cases several years' work has been shortened to as many months by well-organized cooperation in research and the early use of the pilot-plant technique.

*Growing Our Own Fibers and Oils.* Among the major products of agricultural origin that have had to be produced in vastly increased quantities in this country, usually because foreign sources of supply were cut off, are fibers and oils. In some cases, the crops involved have previously been grown in the United States only to a very limited extent, if at all. Thousands of farmers, who have turned to growing one or another of these crops for the first time, had to be shown how. Seed had to be increased rapidly for large-scale production; in some cases there were no commercial supplies of seed. Suitable soils had to be selected. Climatic requirements, cultural needs, disease and insect control, harvesting and processing methods and machinery—all these present problems that must be solved quickly, with a minimum of failures and mistakes, in the case of a new crop urgently needed for war.

In most cases, the research workers already had a stockpile of information that could be put to use at once; even though a crop is not commonly grown in the United States, it is sometimes studied experimentally on a small scale for one purpose or another. It was also possible in some cases to round up experimental stocks of seed and increase them rapidly enough for fairly large-scale planting in a year or two. Needless to say, efforts have been made to fill the holes in our knowledge of these crops and products by intensive research projects designed to develop the needed information as quickly as possible.

When foreign supplies of abacá, sisal, and jute were cut off, plans were immediately made to grow immensely increased amounts of hemp in this country as a partial substitute for these fibers, used for bagging, twines, and cordage. Locations for hemp growing were determined; seed production was stepped up 3,500 percent in 1942; by 1943 there was enough seed for some 200,000 acres, to be planted by farmers who for the most part had never grown hemp before. Meanwhile experiments had gone forward to develop improvements in seed treatment, cultural practices, retting, storage, and other aspects of hemp production.

In the making of marine and other strong, durable cordage, hemp cannot substitute satisfactorily for abacá, or so-called Manila hemp, produced chiefly in the Philippines and formerly imported into the United States to the extent of 100 million pounds a year. As far back as 1925, USDA plantmen began experimenting with selected varieties of abacá in Panama, so that in 1942 they were ready to undertake an immediate large expansion in acreage. Today, some 30,000 acres are being grown in tropical America through cooperative arrangements with Panama, Costa Rica, Guatemala, and Honduras. Increased production of other hard fibers in

Latin American countries is also being actively encouraged.

War immediately focused the spotlight on oilseed crops in the United States by cutting off huge supplies of imported fats and oils and making it necessary for us not only to replace them but to furnish additional huge supplies to our allies.

In the case of soybeans, one of the chief potential sources, the groundwork had already been laid for a greatly expanded production. More than 2,500 types of soybeans were brought to this country from the Orient in the 1920's and 1930's, largely through the explorations of Morse and Dorsett of the USDA; and breeding work in cooperation with the States has been going on actively. The growth of soybean production in this country has been phenomenal—from about 5 million bushels in 1924 to 210 million in 1942 and a still larger acreage in 1943. The United States has now become the world's leading soybean producer, topping even Manchuria, famous as the Land of the Bean.

The jump in production during the last two years, needless to say, has meant a large amount of work for USDA and State plantmen qualified to furnish scientific information for growers, especially those to whom the crop is new. In addition, the research program has been stepped up and, in the South especially, considerably extended. New varieties with higher seed yield, increased oil content, better quality of oil, and good regional adaptation have been tested simultaneously in many locations and introduced as soon as they proved their superior value. Incidentally, it is worth noting that the accelerated adoption of technological advances by farmers in the United States may be a major outcome of the war, and one of great significance, since the chief hope for

*U.S.D.A. Photograph by Forsythe*

SECRETARY WICKARD AND DR. MOHLER EXAMINE A COW UNDER TREATMENT AT THE ANIMAL DISEASE STATION OF THE U. S. DEPARTMENT OF AGRICULTURE AT BELTSVILLE, MARYLAND.

GUAYULE PLANTS GROWING IN GREENHOUSE

U. S. HORTICULTURAL STATION, BELTSVILLE, MD., WHERE REQUIREMENTS FOR GROWTH HAVE BEEN STUDIED.

an expanded and flexible agricultural production in the future lies in technology.

### Help for Consumers at Home

A good example of direct assistance to the public by scientists is the Victory Garden campaign. Not only farmers but suburban and city people had gardens last year, many of them for the first time in their lives; and they naturally looked to the experts, Federal and State, for help. Help was given to the limit of facilities. A Victory Garden bulletin prepared by a USDA plant scientist was in demand to the extent of more than 3 million copies; other printed material on fruit growing and on insect control was widely distributed; and weekly radio programs on gardening reached a large audience, one program alone bringing close to 8,000 requests for answers to specific questions that were troubling gardeners.

The greatest demand from the general public, however, is in the broad field known as home economics. With food rationing, for instance, housewives have faced many new problems in managing food budgets and feeding their families adequately. They had to take shifting food supplies in their stride, going without this, substituting that, and taking more care to prevent waste of all kinds than most of us ever thought possible And this situation not only applies to food; great numbers of items ordinarily used by civilians, including clothing and household equipment, are scarce. Conserving, mending, patching, making over, substituting, and doing without are words that have a meaning never before realized for millions of Americans.

How to cut down consumption of meats and fats and still have nourishing, tasty meals; how to can foods safely; how to de-

DELOUSING THE NEW WAY
A SOLDIER DUSTS HIS CLOTHING WITH LOUSE POWDER DEVELOPED BY THE U. S. DEPARTMENT OF AGRICULTURE.

hydrate foods at home, often with homemade equipment; how to cook with a minimum of loss of vitamins and minerals; how to mend clothes as neatly as our grandmothers did; how to repair a man's suit like a professional tailor, or perhaps convert it into a natty outfit for a woman; how to repair or condition a sewing machine as well as a mechanic could do it; how to make the old refrigerator, washing machine, or electric range survive to a ripe age without breaking down—these are a few of the many questions with which ARA home economists are deluged from day to day during the war. And the public looks to them, not for any answer, but for the right answer, for information that can be used with confidence because it is backed by experience and experiment.

The home economists are drawing on everything they have done in these and other fields, and interpreting it in relation to war needs. Last year the public distribution of their bulletins, leaflets, and other printed material reached a total of 27 million copies —an indication of the extent of the demand for help on the part of the public. In addition, they are developing new research in nutrition, food preparation, textiles, clothing, and household equipment to meet war situations.

### Demands of the Armed Services and Other Agencies

*The Battle of Bugs.* ARA has cooperative arrangements to carry on research for the medical branches of the Army and Navy, the Quartermaster General's Office of the Army, the Bureau of Supplies and Accounts of the Navy, and the War Food Administration; and requests come in from many other Government agencies also.

One of the early challenges was to develop a better means of killing lice, in clothing and on bodies, than the slow, antiquated methods hitherto in use. Specifications were set up for what was wanted, but the military authorities were frankly skeptical that it could be done. It was done by USDA entomologists in about three months' time, largely because of the stockpile of information assembled during many years of research with pests of livestock and crops. A soldier's clothing can now be freed of lice in a few minutes, even at the front, by the use of a fumigant, without the old cumbersome equipment. His body can be kept free of lice by the use of a powder, without the old mass delousing procedures. Lice are carriers of epidemic typhus, trench fever, and relapsing fever, hence this development is a lifesaver as well as a contributor to comfort.

Some of the other major insect enemies of man are in for rude shocks when the war is over and civilians can get materials now used exclusively by the armed services.

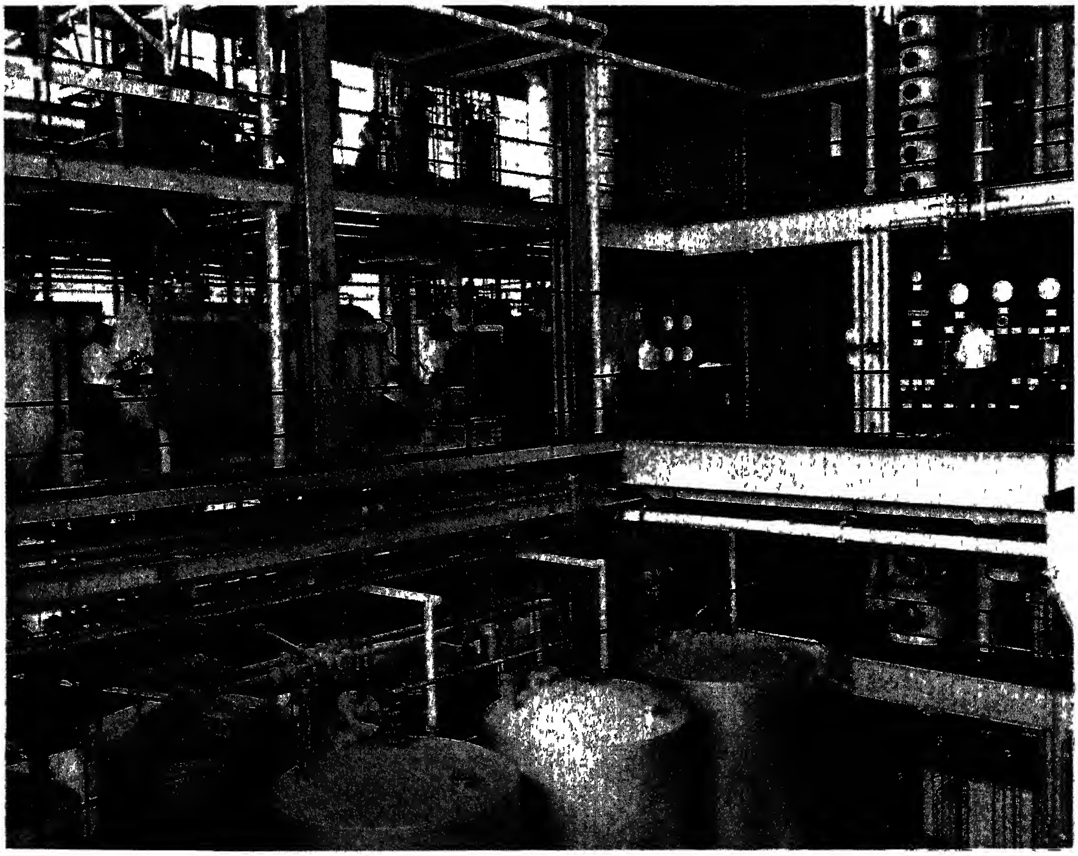
USDA entomologists have developed a method of killing mosquitoes, flies, and other insects in closed spaces—a tent, a room, a barn, a greenhouse—which is more effective and convenient than the old-time sprays.

An insecticide, an activator, and a volatile solvent are mixed and sealed in a small metal container, called a "bomb" because of its appearance. When a valve is opened briefly by thumb pressure, an infinitely fine mist is shot out by the pressure of the volatile solvent which evaporates immediately, leaving the infinitesimal particles of the insecticide floating in the air. They quickly spread everywhere, like an invisible fog. One puff, containing as little as a milligram of the

insecticide, will kill every mosquito in a thousand cubic feet of space within five minutes. And mosquitoes, of course, carry yellow fever and malaria. Immense numbers of these lifesaving bombs have been manufactured and sent to fighting fronts.

*Compact Foods.* The war brought an urgent demand for research in dehydrating foods, for reasons that are obvious—shortage of shipping space; shortage of tin; the need for compact, readily transported food that would remain wholesome under all conditions without refrigeration. Dried foods are not new. Probably every nomadic people has used them. But this time greater quantities of a greater variety of dehydrated foods were needed than ever before, and they had to meet standards set by modern advances in food technology and the science of nutrition.

A third of the Western Regional Research Laboratory at Albany, Calif., was turned into a huge pilot plant to dehydrate vegetables on a semi-commercial scale. Some of the research personnel at this laboratory had pioneered in dehydration years before and had a background of experience. Fairly early in the new program they were able to draw up specifications for several of the more common dehydrated vegetables, as well as blueprints for commercial dehydration plants of various capacities. Two dehydration short courses, one in the West and one in the East, were given for commercial plant personnel, followed by another short course for State Experiment Station personnel, who were being deluged with requests for advice and assistance. In a short time a mass of technical data covering almost every aspect of the commercial dehydration of vegetables



*U.S.D.A. Photograph by Forsythe*

PILOT PLANT, PEORIA, ILLINOIS

SET UP AT THE NORTHERN REGIONAL RESEARCH LABORATORY OF THE U. S. DEPARTMENT OF AGRICULTURE TO TEST ON A SEMI-COMMERCIAL SCALE NEW PROCESSES FOR MAKING ALCOHOL FROM VARIOUS FARM PRODUCTS.

began coming out of this laboratory, to be made immediately available to the industry through technical journals, mimeographed sheets, and otherwise; much of it will soon be published in a bulky dehydration manual. Additional information came from the Plant Industry Station at Beltsville, Md., where methodical studies have been made of the suitability for dehydration of different varieties of vegetables and fruits grown there and elsewhere.

In a word, as solid a technical foundation as could be built in so short a period has been furnished the new industry. The job is not finished. New research is under way, for example, on the compression of dehydrated foods to achieve further space saving.

Meanwhile, work on the commercial dehydration of meat was started at the Beltsville Research Center early in 1942. Livestock specialists, meat specialists, engineers, chemists, bacteriologists, nutritionists, and home economists were drawn in to make a coordinated attack on the problem and to get usable results and a safe, wholesome product as quickly as possible. Within a few months, specifications were drawn up for dehydrated beef and the first commercial bid was asked for by the Government. Pork followed a short time later.

Among other ARA activities in dehydration have been the inspection of egg-drying plants and improvements of the product; improvement in the packaging of whole milk powder, to overcome the difficult problem of oxidation of the fat in the milk, and, very recently, the development of a new method of dehydrating whole-milk cheddar cheese, which gives a superior product, easily shipped and handled, and with all the quality of the natural cheese.

This brief account covers only the work of the Agricultural Research Administration and only a little of that. Other agencies, the Forest Service, the Soil Conservation Service, and the Tennessee Valley Authority, for example, have also been engaged in agricultural research during the war; and the State experiment stations in particular have contributed a mass of information on the problems of producers and consumers in their areas.

Much of this work, needless to say, will have a marked effect on production practices and on consumer products after the war, when we are ready once more to turn swords into plowshares; but just what the effects will be, and how extensive, the scientist usually prefers not to guess. In the first place, too many economic and social factors that he cannot fully evaluate are involved. In the second place, he has been too immersed in urgent war problems to think much as yet about those of the post-war period. We badly needed such things as dehydrated foods, synthetic rubber, and soybean oil. Research made it possible to have them. The same research will be called on to meet vital post-war needs, and it will be ready.

# PICKLE HELICTITES

By RAYMOND E. JANSSEN

In geology "helictite" is the name given to a curious twisted form of stalactite. The growth of helictites in caverns is an intriguing subject of recent investigation among geologists, and experiments in producing them artificially in the laboratory have been made; for example, by Lyman C. Huff (*Journal of Geology,* 48: 641–659, 1940). Closely resembling helictites in appearance are some curious growths which I observed and photographed on the jar lids of several bottles of home-canned pickles stored in the basement of my mother-in-law's home. Like helictites, these show irregular growth patterns; but instead of growing downward or laterally from suspension, they grew upward. Also, these growths seem to occur both in a crystalline and in an amorphous structure. The crystalline forms are solid or spongy and are extremely delicate (Fig. 1), and the amorphous forms are more or less hollow and considerably more sturdy (Figs 3 and 4). Both forms may occur in close association on the same lid (Fig. 2).

The first growth of this nature was discovered by my mother-in-law one day when she went to her basement for some jars of her canned goods While visiting at her home, my attention was called to the strange growth. I photographed the specimen first and then, upon examining it, I found that the growth had its start in a minute pinhole which had developed near the top of the zinc jar lid. Apparently the hole had been eaten in the lid as a result of chemical reactions which had taken place within the jar during the months since the pickles had been canned.

There are two possible causes for such chemical reactions in the pickle brine. First, the jar may not have been perfectly clean or impurities may have gotten into the brine at

FIG. 1. CRYSTALLINE HELICTITES
DELICATE FORMS EMERGING FROM PIN-HOLES IN LID.

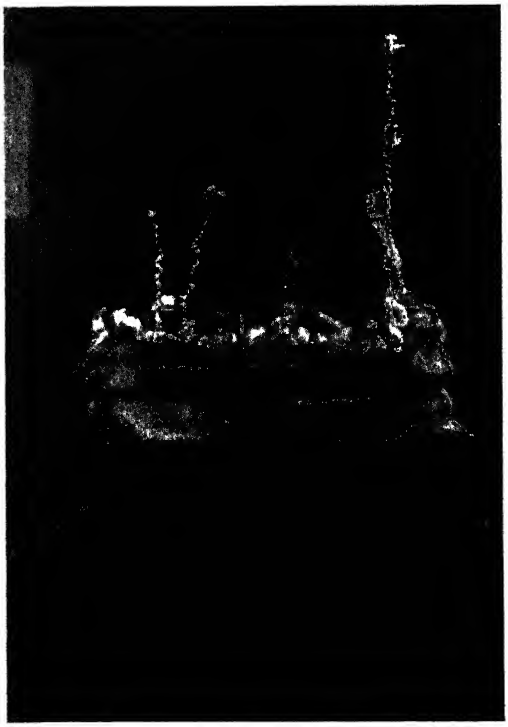


FIG. 2. TWO FORMS OF HELICTITES
CRYSTALLINE AND AMORPHOUS ON THE SAME LID.

the time of canning. Second, the jar lid may not have been secured tightly or may later have been disturbed so that air was able to enter subsequent to canning. If the latter was the case, the jar must later have become resealed in order to permit gas pressure (evidenced by the bulged lid) to have been built up inside after the chemical reactions began. The latter seems more likely for two reasons: First, all of the jars of this canning batch were not affected. Second, a white carbonate precipitate was formed inside the jar, filling the space around the threads of the lid. This area, of course, is the place where resealing would have to occur in order to make the jar airtight.

The corrosive brine within the jar may have come into contact with the underside of the zinc jar lid in one or more of three ways: first, by bubbling of the liquid during reaction; second, by capillarity of the liquid upward along the inside of the jar and lid; third, by splashing the inside of the lid at the time of canning or by condensation of water vapor on it later, either event providing a wet surface for the solution of acid gases or vapors. Contact of this liquid with the zinc produced zinc acetate and zinc carbonate, of which the strange, helictite-like growths and other precipitated material on the outside and inside of the lid were composed.

Whether these "stalks" grew from their tips or by accumulation and upward pushing from their bases is not known because the reactions which caused them had apparently stopped before they were observed. If they grew from their tips, capillarity along the entire length of their stalks must have been responsible. There is some suggestion, however, that they might have grown from their bases. When the pinhole first opened, the gas under pressure beneath the lid must have escaped, and may have driven a solution of zinc salts through the hole and left a droplet to evaporate above the hole. The residual solids may have sealed the hole, thus permitting gas pressure to build up again under the lid. If, then, the pressure became sufficient to break the seal, more solution may have been carried up through the pinhole and left under the first plug of zinc salts. Upon evaporation the resulting plug might have carried the first plug on top of it. Repeated, alternate sealing of the hole and eruption of gas might have thus built up the solid, crystalline helictites.

The irregular, zig-zag pattern of the solid stalks, which could have been caused by unbalanced deposition of solutions, are best explained by assuming the occurrence of successive eruptions of gas. The development of these helictites might be likened to the growth of the chemical "snakes" which children set off among their Fourth of July pyrotechnics. Also, the material making up the "tufts" at the tips of the stalks is similar in form and composition to that which is incrusted on the jar lid, indicating that it may have been formed first and then may have been carried upward at the tip while the stalk grew in length from below. This general incrustation around the outside bottom of the jar lid is not uncommon on jars of home-canned pickles, and seems to form as a sort of "frost." In certain jars liquid oozed past the rubber washer, dribbled down the outside of the glass, and left a streak of precipitate all the way down the outside of the jar. In some cases, such precipitate is known to have formed before the formation of the helictite-like growths

Several months after the first helictite-like specimen was discovered, similar growths were found to have appeared on several other jars belonging to the same batch of pickles. All these growths occurred on jars which had been canned during the summer of 1937. These jars had then been placed on a shelf about six inches above the floor in a cool, dark, damp corner of the basement. Most of their contents were consumed by the family within the next season or two, but several jars remained untouched until February, 1940, when the first growth was observed and photographed (Fig. 1). At that time there was no indication that any of the other jars of pickles was in the process of spoiling; hence they were allowed to remain on the shelf. It was not until August 30, 1941, that the growths shown in Figures 2 and 3 were discovered. Since these growths were not anticipated, no observations of the jars had been made during the interval; hence it is not known how much time was required for the growths to attain their pictured state of

FIG. 3. TUBULAR AMORPHOUS TYPE

FIG. 4. NINE MONTHS LATER

development. That they attained their growth solely within the period from February, 1940, to August, 1941, however, is established.

One of the most interesting of these growths is the tubular form shown in Figure 3, together with the secondary spine which later emerged from within the tube (Fig. 4). In miniature, this primary growth was not unlike the formations which are built up around the surface openings of geysers and hot springs. This specimen was first observed and photographed on August 31, 1941. It was then replaced in the same position on its shelf in the basement, and again observed and photographed on May 31, 1942, at which time the secondary growth, approximately 1½ inches long, had emerged from the hollow of the original growth. Unfortunately, this secondary spine was not observed until after growth had stopped.

The materials that gave rise to these curious, helictite-like growths included vinegar, salt, sugar, mustard seed, celery seed, and onions in addition to the cucumbers. The canning was done hot, and the jars were filled up to the brim with brine.

The close resemblance of these growths to cavern helictites may, or may not, be significant. The conditions that existed in the dark, damp, slightly drafty basement where they grew were not vastly unlike those prevailing in a cavern. So far as known, such growths have not heretofore been reported. Because of their remarkable similarity in appearance to some helictites, I have chosen to call them by the absurdly appropriate name of "pickle helictites."

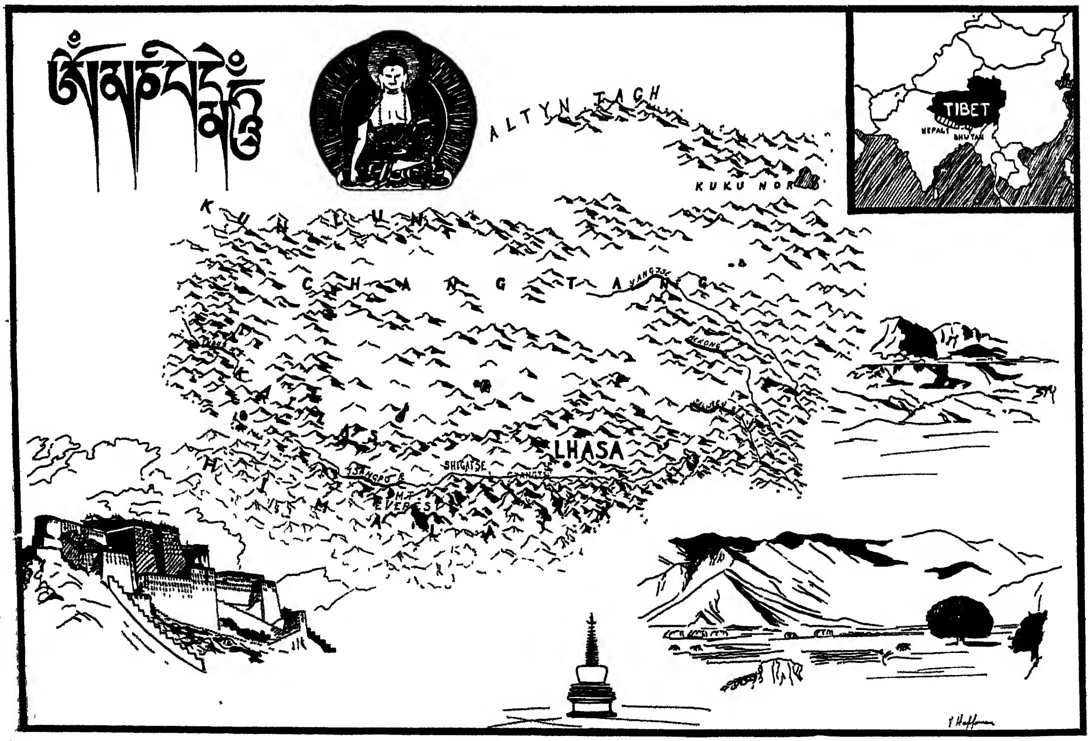
# THE FORBIDDEN LAND

By MARY ELLEN GOODMAN

In the days when the cautious, and perhaps very wise, Chinese induced the Dalai Lama to close his country to the "White Devils," Tibet became to Europe a legendary forbidden land. Those incautious souls who defied its regulations and dared its rigors found it no less forbidding than forbidden. From the Himalaya and the Karakoram on the south and west to the Kun-Lun, Akka-Tagh, and Altyn-Tagh on the north, the Tibetan borders are defended by the world's most formidable mountain ranges. Across these vast heights, tremendous open plains, and treeless valleys sweeps a howling wind from mid-morning until sunset. During perhaps four months of the year the milder parts of Tibet are free from frost. Between October and May there is very little precipitation, but in July and August there are occasional violent thunderstorms, particularly on the western highlands and northern plains. Hence the chief supply of water comes from the fairly numerous rivers fed by melting snows. Springs are rare and usually thermal and sulfurous; the lakes, while numerous and sometimes very extensive, are often brackish. "Natural" trees occur but rarely, save in the extreme south and east of Tibet. Elsewhere the barren, stony or icy reaches produce only a few stunted bushes, a rare willow or cottonwood, coarse grass and, in the higher altitudes, moss. The natural fauna—sheep, bharal, gazelle, wild ass, wild yak and even the domestic yak—subsists mainly upon the moss.

Of Tibet's 700,000 square miles, six-sevenths are estimated to be uninhabitable. Its population of three to four millions, few of whom probably reside at an altitude below 10,000 feet, is concentrated in the southern and eastern portions of the country (Fig. 1).

The northern plain, the Chang Tang, is




Drawing by Virginia Hefferman

FIG. 1. TIBET—THE FORBIDDEN LAND

peopled only at its southern border. Elevated to 16,000 feet and more, it produces no crops or trees, and boasts little of value to man save salt lakes rich in potash, borax, and soda.

In the river valleys of southern Tibet are the cities and converging "highways," the farms and the better pastures. This area falls away to a mere 10,000 feet, and woods and the less hardy crops flourish. In south central Tibet lie the three principal cities: Shigatse, Gyangtse, and Lhasa.

Eastern Tibet, deeply carved by great river valleys, slopes to 6,000 feet. Here is the most fertile part of Tibet. Such trees as willows, poplars, and cottonwoods are planted and cherished in walled parks. In private gardens walnuts, apricots, peaches, apples, bamboo, cypresses, and pines are grown. Except for the walnuts, the fruit borne is small and poor. Vegetables such as cabbages, peas, beans, potatoes, turnips, and radishes are here produced, as well as a variety of imported garden flowers. Forests, water, good grazing, and mineral wealth are more abundantly available than elsewhere in this elevated land.

As to the people themselves, they are believed to have come originally from the northeast, from the vicinity of Kuku Nor. These early Tibetans were doubtless pure pastoralists, and of a physical type still best represented among the pastoral tribes (Fig. 2). The sedentary peoples show Chinese admixture in increasing concentration toward China, and Nepalese, or Kashmiri toward the southwest. The "primitive" type is probably the short, brachycephalic Mongoloid, though dolichocephals are frequently observed, particularly among the upper classes and the priesthood.

Native tradition ascribes Tibetan ethnic origin to an ape-god and a female demon, and the flood motif is not lacking. According to Chinese tradition, the early Tibetans were an inferior people driven out of China to the vicinity of Kuku Nor in the twenty-third century B.C. Tibetans attribute many of their more complex culture traits to their traditional first king, who came from India in the first century B.C. The Tibetan alphabet is said to be based on the Indian as used

FIG. 2. NOMAD IN MARKET PLACE*
IN TYPICAL TIBETAN FASHION HE BARES HIS RIGHT SHOULDER DURING THE WARMER HOURS OF THE DAY.

in Kashmir, while the major linguistic affinity of Tibet is with Burma. The complication of Tibetan culture above the postulated original pastoralism may be attributed largely to borrowings from China and India, the former being the chief source of material culture.

The modern line of Tibetan "priest-kings" was begun in 1270 by decree of the Great Khan, who, having been converted by the high priest of a large Tibetan monastery, indicated his approval of this gentleman and his good works by turning over to him the sovereignty of his country. Three or four centuries earlier the Tibetan nobles had adopted Chinese silk garments, surrounded themselves with Chinese scholars, sent their children to study the classical literature of

* All photographs are reproduced by courtesy of the Peabody Museum, Harvard University.

China, and had workmen brought from Singan to make paper and ink. In the eighth century they had threatened the power of China itself, but their kingdom became dismembered by civil wars as a result of the conflict between civil and priestly powers. Then followed a period of persecution of the religious leaders, during which Buddhism was suppressed for some seventy years, only to rise triumphantly with the support of Kublai Khan, and China has since not ceased to support the "clergy." The finger of Chinese political influence has never been entirely absent from Tibetan affairs, though a marked diminution of the pressure took place with the ascendancy of the star of British political fortunes in this area, and with the 1911 revolution in China.

European influence has brought into Tibet (most particularly in Lhasa) such cultural innovations as kerosene lamps, an electric plant and its limited use for lighting, a wireless transmission set, a postal and telegraph system, soap, tooth brushes, silver tea sets, the gramophone, and a slight tendency among the gentry to observe European social habits.

FIG. 4. TOWNSMAN IN WOOLEN GOWN HOLDING A PRAYER TRUMPET AND A PRAYER WHEEL.

FIG. 3. PEASANTS IN SHEEPSKIN GOWNS WOOL TURNED INWARD. ONE WHIRLS A PRAYER WHEEL.

These innovations are, however, extremely limited in scope. Tibetans in general have apparently changed their ways but little since the major revolutions induced in their lives by the introduction of tea and of Buddhism, of which the former was perhaps the more revolutionary.

As to economy, there is to be found among Tibetans a range between near-subsistence nomadism and highly-developed business enterprise involving full-time traders, financial experts, and the basic principles of European commerce.

From the viewpoint of modes of subsistence, Tibet divides itself into the region of tents and that of houses. This division rests primarily upon geographic and climatic factors, tents being pre-eminently the dwellings of the nomad herdsmen, though some few of the latter live in houses. Toward the south and east, in regions suitable for agriculture, tents mingle with stone houses and are gradually entirely displaced thereby. Semi-

commercial economy prevails in both spheres, however, the herdsman exchanging his surplus commodities for those of the peasant, without which he could scarcely survive, and both depending to some degree upon imported articles, especially tea. The peasant household may be expanded to the scope of the feudal estate, on which the farmer exchanges a part of his labor for commodities, but the economic unit is in any case essentially the domestic one. Even manufacture for export, as of Tibetan carpets, takes place within the feudal household.

Pastoralism having been identified with the tent, a survey of this mode of subsistence might well begin with a closer inspection of this shelter. It is fabricated by the Drok-pa and his family, and, by its durability, portability, and wind resistance, is excellently adapted to his mode of life. The Tibetan tent is of black yak-hair fabric in two pieces brought together at a horizontal ridge-pole. Between these an aperture is left for ventilation and the escape of smoke. The ridge-pole is supported by a pole at either end; the cover is tightly stretched by cords fastened to the sides and corners, which are passed over short poles some distance from the tent and firmly pegged down. The lower edge, too, is held down by iron pins or animal horns. The tent may be twelve to fifty feet in length, housing usually five or more persons, and is rectangular in shape. About it a wall of mud, stone, or dung serves as protection against wind and snow, as a convenient fuel supply, or as protection against brigandage. In places of longer occupancy the walls of the shelter may be of sod or stone with a felt roof, while temporary wall shelters may be built up of whatever materials are at hand—perhaps the bales of wool being transported to market—and left open to the sky.

In the center or near the entrance of the tent will be found a stove-like structure of mud or stones on which a brass kettle or two will be set over a dung fire. Along the walls, or stacked to form recesses, are cooking utensils, buckets and churns, rugs, strips of felt and blankets for bedding, saddles, and leather bags containing food. Pails of milk, cream, curds and cheese stand about, and perhaps a basket of tea leaves once used and saved for another service, as well as a collection of bones, one bone from each animal eaten having been preserved. At the back of the tent is the "cupboard of the gods" before which lies a large block of wood which constitutes the place of honor in the house. At this shrine a butter-lamp burns to the "Great Name."

The peasant is sheltered by a flat-roofed structure of stone slabs held together with mud, or of sun-dried bricks. These windproof walls have only few and very small windows, if any. The better homes boast wax cloth, paper or, rarely, imported glass in the windows. In any case the windows are nearly always covered with wooden shutters. The homes of the poor have a yard at the front or back, but the houses of the prosperous are arranged around an inner court and may boast several stories. In the latter case the ground floor may be completely covered and serve as a stable and storehouse, while on the first or second floor will be a verandah, consisting merely of a room of which the outer wall has been removed.

FIG. 5. TIBETAN LAMA
WEARING THE PEAKED HAT OF HIS PARTICULAR SECT.

Access to upper stories is gained from the courtyard by rough stone steps, a ladder, or a notched log. The roof is of beaten earth or, in forested areas, of long, pine shingles weighted with stones. In large rooms wooden pillars, sometimes carved and painted, will be used as interior roof supports. The roof is a functional part of the Tibetan home: there will be found prayer flags, a pot of incense, firewood, drying pots, perhaps onions growing in boxes, and a chained watchdog. No bolts or nails are used, and as Bell states in *The People of Tibet*, "dovetailing is an art which is thoroughly understood." Floors are of small pebbles and earth beaten down and polished with oil, or of roughly smoothed planks A tendency toward colorful architectural embellishment is notable in the decoration of the great wooden gate by which ingress to the more pretentious homes is usually gained. This gate may be beautifully carved and brightly painted, perhaps with the swastika significant of durability, or the traditional "Mongol Leading Tiger" scene for luck.

Furnishings of the homes of the well-to-do farmers will include a few small tables, heavy wooden chests arranged along the walls and some mattresses stuffed with wool or straw and bound in cloth. Every home of any pretensions must have a "religion room." In the house of the farmer it will contain his better clothes, the ornaments of his women, and other valuables stored in chests or cupboards, some images, and butter lamps. The homes of the wealthy may contain two or more such rooms, elaborately furnished with ritual objects, art objects, sacred books, and so on; the walls and ceilings may be covered with cotton cloths or Chinese brocades, while the floors will be thickly carpeted with woolen blankets, Tibetan rugs, and large pieces of felt. Art and religious objects, often of Chinese workmanship or inspiration, predominate among the furnishings of the better homes. Functional furnishings are apparently rather few.

The house of the farmer, like the tent of the nomad, is likely to be situated on high and sloping ground. The great city mansions may be on the level plain, however, and are usually surrounded by a grass-carpeted park in which a few trees are cherished. Here may be a little "pleasure house" which becomes the center for outdoor entertaining, especially during the summer.

There is yet another class of structure: the great public buildings of the metropolitan centers. Greatest of these is the Potala, the monastery-palace of the Dalai Lamas. The lower walls of such buildings are of granite; the upper, of mud bricks partially surfaced with red-dyed mortar on which golden monograms and emblems may be effectively set. Interiors of public buildings are said to be disappointing. According to F. Spencer Chapman, "Dark passages, slippery with centuries of spilling of Tibetan buttered tea, lead with no apparent design from assembly hall to shrine, and from temple to private apartment." However, color is again to be found in the painted beams and pillars which support the ceilings. The arch is not used, and upon the square poplar pillars rest transverse willow poles laid a foot or more apart, and above these, smaller branches are laid at an angle, giving a pleasing herringbone effect. Above the branches is laid the flooring of the upper story.

As the forms of shelter reflect the diversity and complexity of Tibetan culture, so also, though to a somewhat lesser degree, do modes of dress and personal adornment. These are matters of considerable importance to both sexes, and are indicative of social and economic status, occupation, and locality. Brilliant colors and rich fabrics are preferred, with emphasis among the gentry upon imported Chinese silks, embroideries, and furs. The standard article of clothing, for both sexes and all classes, is a very full gown with a high collar and very long sleeves. Among the herdsmen of the north it is most likely to be made of unlined sheepskin (Fig 3), perhaps adorned with edgings of panther skin or colored wool. Among the peasants it may be of yak hair or leather, and in the towns of blue or dark-red wool (Fig. 4), or of silk, perhaps fur-collared, while among the lamas it is colored red or yellow, depending upon the order to which the individual belongs. In summer this gown may be of native cloth or of imported silk; in the winter, of sheepskin or cloth lined with lambskin or wadded cotton, depending upon the re-

FIG. 6. A GROUP OF WOMEN WEARING THEIR HAIR IN THE TRADITIONAL 108 BRAIDS
THIS HAIRDRESS WAS SUGGESTED BY THE 108 VOLUMES OF THE "KANDYUR," THE TIBETAN BIBLE OR CANON.

sources of its wearer. Always it is tied tightly about the waist with a woolen, cotton, or elaborate silken band, and bloused above. The capacious "pocket" thus formed is likely to bulge with a collection of personal oddments. The robes of workers will be pulled up to the knee; those of the gentry, priests, and women will fall to the ankle. Beneath this gown may be worn a sleeveless shirt and perhaps a waistcoat of any of the available materials. Over the gown, in central and eastern Tibet, the women wear a broad, varicolored apron. The ceremonial dress of chief lamas and officials is more likely to be Chinese in both pattern and material.

Shoes are of two types: Chinese and native. The latter have "uppers" of Tibetan cloth, felt, or leather, usually varicolored and reaching to the knee. The soles are made of thick rope or raw yak skin. Chinese boots are of mid-calf height, with velvet tops and leather soles.

Headcoverings assume a great variety of shapes and types. In winter they are preferably furred, but felt is the material most widely used, with cloth a close second. The people of eastern and northeastern Tibet often go bareheaded, while the nomads may cover their heads and ears simply with a strip of sheepskin. On their shaven heads

FIG. 7. A TIBETAN LADY

FIG. 8. EXAMINING CHINESE BRICK-TEA

the lamas are likely to wear a peaked cap, variable as to size and color (Fig. 5).

Personal adornment of less functional nature goes chiefly to the head, particularly of women. The hair of nomadic women is decorated with three ornamented bands reaching nearly to the ground, or worn in the traditional 108 braids (Fig. 6). On the forehead may be worn a large jewelled disc. Sedentary women more often wear their hair twisted and twined through large and cumbersome wooden frames, or parted in the center and built out into a huge wedge on either side. Men, especially herdsmen, wear rings in their hair as well as an ornamented band fastened to the queue, which is worn wrapped around the head or hanging loose.

Finger-rings, charm-boxes, necklaces, and earrings are nearly universal (Fig. 7). A large silver ring or drop, set with semi-precious stones, is usually worn in the left ear, while a rough turquoise is worn in the right ear. The charm-box is a more or less elaborate and heavy affair worn suspended about the neck and containing script and pictures especially prepared by a lama for the warding off of colds, coughs, and other bodily ills.

The Tibetan, especially the nomad, usually carries in the pocket of his gown such accessories as a knife, a needlecase, a tobacco-box, a pipe, a cup, a powder-horn, and a tinder-box. In many districts it is no doubt both prudent and customary to carry about the person a weapon of some sort. While the bow is the traditional heavy weapon, the sling is apparently now in most common use among the poor. A straight, two-edged sword, perhaps a long rapier stuck through the belt, and a six-foot lance with an iron head and light shaft complete the armory.

"Man does not live by bread alone," but in Tibet, by all accounts, he might almost live by tea alone. Chinese tea, beaten up with butter and flavored with salt or soda, constitutes the staff of life for Tibetans, rich and humble (Figs. 8, 9). Their capacity for this beverage is apparently infinite; writers disagree only as to whether the consumption is thirty to forty or seventy cups a day. This tea is invariably black and inferior in qual-

FIG. 9. CHURNING BUTTER AND TEA

FIG. 10. THE YAK, MOST USEFUL ANIMAL OF TIBET

ity. Buttered tea, dry cheese, and the flesh of wild and domestic animals constitute the bulk of the food of the pastoral peoples. Their vegetable food consists mainly of a radishlike root, which is said to grow to altitudes of 14,500 feet, and barley and millet imported from the agricultural districts. Millet may be mixed with buttered tea and made into cakes called tsamba. Very little milk is drunk, and pork and poultry are used only in the agricultural regions.

To the prosperous in urban areas are available all the resources of the herdsman, hunter, and peasant, plus a not inconsiderable variety of imported foodstuffs. On an official visit in a wealthy Lhasa home, Chapman recounts having first been served, in the "main sitting room," with a preliminary meal of tea, dried fruits, sweets, and biscuits. Later the main meal was brought in: there were dishes of boiled mutton, yak tongues, preserved prawns, dried fruits, small nuts and sunflower seeds, sea slugs, sharks' fins, mushrooms, bamboo roots, meat balls, stuffed eggs, and quantities of barley beer. This food was in general highly seasoned and was eaten with chopsticks.

Butter is made from the milk of the sheep, the goat, the yak, the yak-cow hybrid, or the cow. That of the yak or hybrid animal is preferred. Butter is clarified and sterilized by boiling. The buttermilk is then boiled and the curd strained out, wrapped in cloth and pressed with heavy weights to further dehydrate and shape it. Later it is cut into cubes through which a yak-hair string is passed, and these cubes are hung up to dry. In this condition it can be kept indefinitely and provides an excellent source of nourishment for the traveller. The whey left over from this process is given to the calves or dogs and is sometimes utilized by the people. Food preservation is not a major problem. It is said that in the dry, cold air meat may be kept two to three years and grain two to three hundred years!

The fields of the Tibetans are usually in the protected valleys. They are small and rather poor, but fair yield is obtained since climatic conditions preclude the production of more than one crop per year, and crop rotation, fallowing, and fertilization are practised. Furthermore, some alluvium is deposited by the action of irrigation waters channeled off the streams and rivers.

Barley is pre-eminent among Tibetan

cereals and is the chief upland crop. Wheat, peas, mustard, buckwheat, maize (a staple in eastern Tibet), radishes, and turnips are other crops of main importance. Rain in May and June is essential to the crops; should it fail, the government supplies lamas to hold "Rain-Bringing Services." These dignitaries go to the sacred springs where there dwell beneath the ground the serpent spirits in whose charge are water, trees, crops, flowers, and treasures. At these spots they hold ceremonies. When permission has been given, by the Dalai Lama or other officials, harvesting may begin. This is a period of intensive labor when the entire family rises and goes to the fields an hour or two after midnight. There they labor until sunset or longer. Once the crops are in, a day is spared for feasting and celebration.

Threats to the crops are numerous and must be averted by both empirical and magical measures. Frost is the greatest enemy, and in late August the farmers pray for cloudy nights and the government sends out priests with "frost-prevention" jars, which are ceremoniously buried on mountain tops. These contain bits of barley, silk, gold, and silver, and their preparation is attended by magical rites. Locusts are not unknown. They are regarded as incarnations of a class of beings dwelling in the fifth lowest of the six worlds. There they are tormented with perpetual hunger and thirst for having been covetous, gluttonous, and uncharitable. Rats may also do considerable damage. Hail—attributed to the warring of the elements of wind, fire, and water—is a major menace and is believed to fall mainly in regions where the inhabitants are quarrelsome or where many illegitimate children are born. The Ngakpas, a group of practitioners especially versed in the proper charms, are employed to prevent hail. General precautionary measures for the safety of the crops include the burning of incense on the house tops in the early morning, particularly in the first half of the month other than the first day, general prayers, and processions around the villages with the carrying of prayer banners, sacred books, and other ritual objects.

The peasant may be an independent small landholder, but he is more likely to be bound to the soil in a feudal tenancy relation to a great landowner, either private or corporate (as one of the large monasteries). He is in the latter case unable to leave without the landlord's permission, which is not often given and must usually be bought. Penalties for unlicensed departure are severe, and, furthermore, the spirits of the village are likely to be wroth should the native leave his soil. Agricultural labor is apparently at an even greater premium than arable land.

Cultivating communities preserve grazing grounds for the stock they must keep for draft and food. Essentially communal, the grazing grounds are subdivided and allotted by the throw of dice. Their use rotates, and the rents charged therefor, which differ for different animals, go into a communal fund. Farm animals are likely to be yaks and other cattle, ponies, mules, donkeys, dogs, and some pigs (the latter usually kept by the Chinese). One or more Newfoundland-size, shaggy, black-haired watchdogs are usual at every house. Ponies are kept for riding and transport, as are mules and donkeys. The latter are cheap, and all men can ride. The yak and its cross-breeds are the most useful of Tibetan animals (Fig. 10). They furnish foods of flesh, butter, and cheese; transport for both men and goods; wool used in the manufacture of ropes, felt and textiles, and blankets; hides for clothing, trunks, bags, and boats; dung, which is Tibet's only significant fuel supply; and even a primary article of Tibetan export, namely, their tails. These may become ritual objects in Hindu temples or merely fly whisks. Noteworthy is the fact that they are especially prized when white.

(*To be concluded*)

# CORK CULTURE IN THE UNITED STATES*

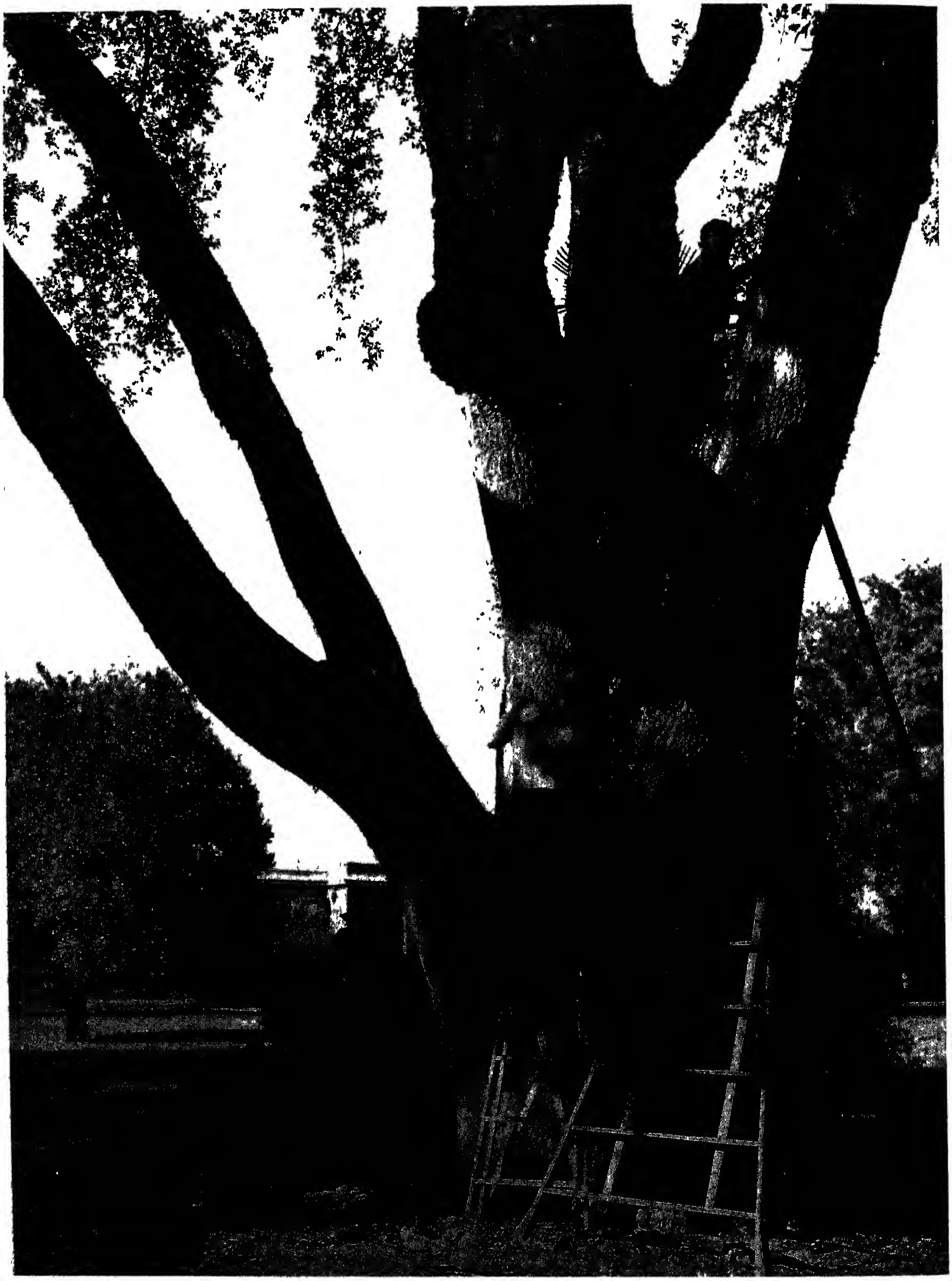
By GILES B. COOKE

Cork is a critical war material and a necessary peacetime commodity. For prosecuting the war, cork is needed for cartridge plugs, bomb parts, insulation, gaskets of numerous kinds, and many other articles essential to a modern army and navy. Non-military uses of cork are numerous and include corkboard insulation, stoppers, liners for bottle caps, life preservers, inner soles for shoes, gaskets of many types, and various other articles.

At the outbreak of the present World War, all private cork inventories within our country were taken over by the United States Government. Use of the limited amount available was controlled by government agencies, and only by sharply restricting non-military uses of cork was the supply made to meet defense needs. Owing to the neutrality of Spain and Portugal, a limited amount of cork was brought to the United States during the first three years of the war. Rigid rationing has enabled wartime imports to meet essential requirements. The liberation of Algeria and the control of the Mediterranean by the United Nations improved the cork situation and eased the four years of tension. However, the cork situation today is very unsettled and the use of cork is still regulated by the War Production Board.

* All illustrations courtesy, Crown Cork & Seal Co.

LARGE CORK OAK GROWING IN GEORGETOWN, GEORGIA



STRIPPING THE LARGEST CORK TREE IN THE UNITED STATES

THIS TREE, GROWING ON THE GROUNDS OF THE STATE HOSPITAL IN NAPA, CALIFORNIA, MEASURES 58 INCHES IN DIAMETER AT BREAST HEIGHT AND IS 75 FEET TALL. IN JULY, 1943, CORK WAS REMOVED TO A HEIGHT OF 17 FEET AND 1,050 POUNDS OF GOOD CORK OBTAINED, LARGEST QUANTITY TAKEN FROM ANY U. S. TREE.

Practically every adult person in the United States has used or observed cork in the form of bottle stoppers or crown cap liners. Only a limited few are familiar with the source and production of this essential product of nature. Cork is the bark of the cork oak tree which grows along the shores of the Western Mediterranean, being indigenous to the soil and climate of this region. Since man first learned to utilize this unusual bark of the cork oak, the world's supply has come from this limited area.

For normal peacetime manufacturing requirements in the United States about 160,000 tons of cork are imported annually. In 1937 the value of unmanufactured cork brought into the United States was seven times the figure for 1899, thirty-eight years earlier. This increasing demand for cork products here, as well as abroad, has had its effect on the cork-producing countries, and special efforts have been made to conserve cork forests and properly market the harvest. Numerous scientific papers relating to cork culture have appeared, particularly in Portugal, during the past three decades. This attention to corkwood has resulted in a large increase in cork production in practically all the cork-producing countries.

Attempts have been made by other countries to grow the cork oak. Experimental plantings of cork trees have been made in Australia, Uruguay, Argentina, Japan, Russia, and the United States. These countries realized the importance and economic value of having cork trees growing at home. Only limited information is available regarding the extent of the plantings or the results obtained outside of the United States. It is entirely possible that after a reasonable time for growth elapses sufficient cork for essential requirements will be produced in some of these countries.

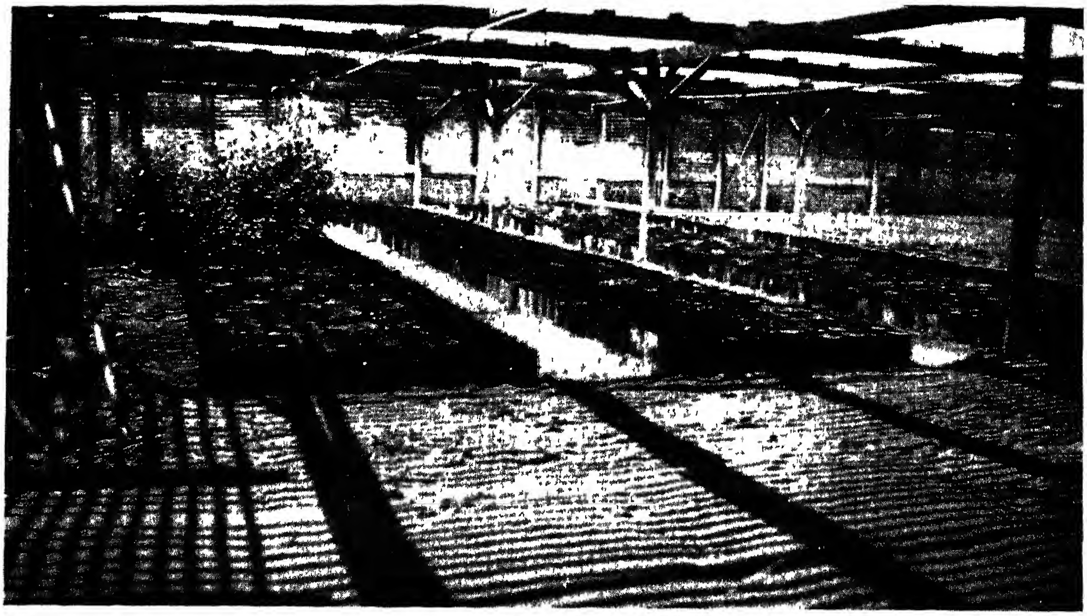
The need for a domestic source of cork was apparent to the founders of our government. At the same time they were fully aware that the soil and climate of the southeastern states were suitable for growing cork trees. In 1784 Thomas Jefferson was sent to France to aid in the negotiation of trade treaties. While there he was elected to honorary membership in the Agricultural Society of South Carolina. Jefferson acknowledged the honor with thanks and at once went to work as a very active member. In February, 1787 he sent a package of cork oak acorns to William Drayton of "Magnolia" at Charleston. These cork acorns were received by Drayton and planted but no trees were obtained from them. The acorns were three months in transit and, based on present day observations, were, without doubt, nonviable when William Drayton received them. For forty years Thomas Jefferson labored to establish the cork oak in the United States. In April 1826, six weeks prior to his death, he wrote to Dr. Emmett, Professor of Natural History, University of Virginia, recommending the planting of cork trees.

*Holmes I. Mettee*

CHARLES E. McMANUS

ORIGINATOR AND SPONSOR OF CORK PROGRAM IN U. S.

The United States Government became interested in planting cork trees about 1858. Cork oak acorns were obtained from Spain by the Patent Office (the United States Department of Agriculture was not established until 1862) and distributed in the southeastern states and California. Many of the acorns and young trees of this planting were lost. However, a few trees survived and from a United States Department of Agri-



NURSERY AT SUPERIOR, ARIZONA, GROWING 50,000 CORK OAK SEEDLINGS ANNUALLY

culture report written in 1877 by F. B. Hough we read:

> In 1858 and, it is believed, at an earlier period, quantities of acorns from the cork oak were procured from the south of Spain and distributed from the Patent Office to those sections of the country where it was thought they would thrive. A report made at the close of 1875 from Winnsborough, South Carolina, shows that all the acorns planted in 1859 came up and made healthy plants. Three of these are now 24 feet high and over 27 inches in circumference. Two trees, at least, are flourishing at Orangeburg, South Carolina, and there are probably elsewhere in the South examples of successful planting of this tree. The cork oak requires a warm climate, but the southern states and California appear perfectly well adapted to its wants.

Some of the cork oaks that survived this early planting are today magnificent specimens, having large trunks with wide limb spread.

In 1880 more cork acorns were obtained and distributed to many places in the southern states, Arizona, and California. While some trees from this planting are still alive, many of them were lost. From time to time a few cork trees have been grown through private effort. Also, local plantings have been made in several states. A substantial planting at Chico, California, in 1904 has resulted in more than 600 cork oaks—the largest stand of cork trees in the United States. In 1914 some cork acorns were obtained from Portugal and planted in northern Florida. A substantial number of trees were obtained, but a severe storm a few years later destroyed most of them.

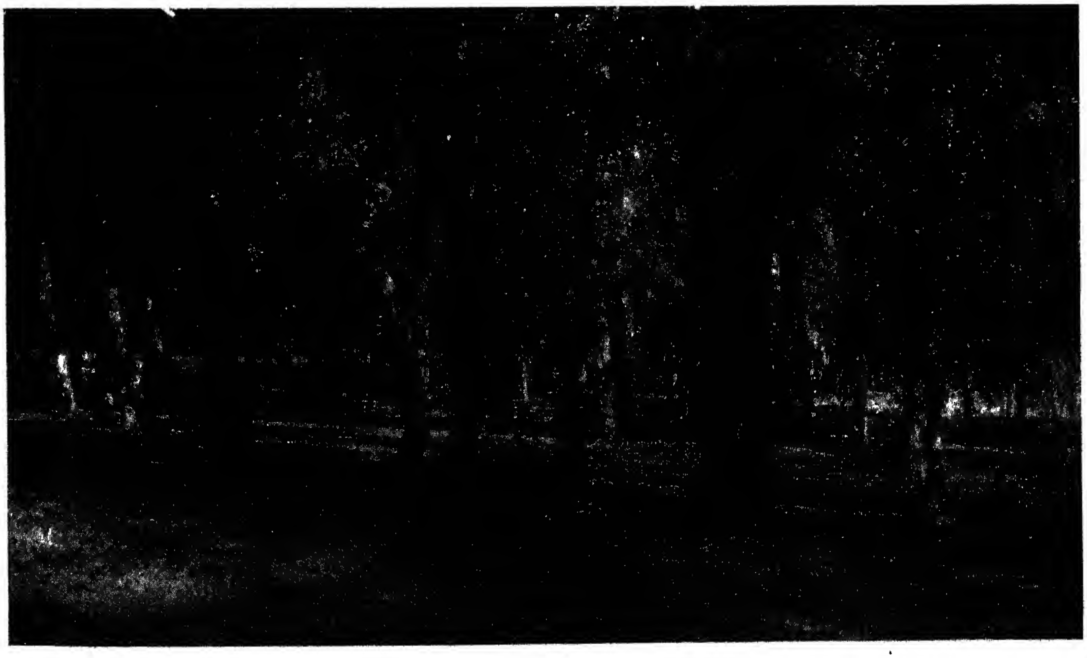
Some time ago, Charles E. McManus, President of the Crown Cork and Seal Company, examined a number of these cork trees and at once recognized the good quality of the cork. Realizing the possibilities of a domestic source of cork, he established a Cork Project to promote the growing of cork oak trees in the United States. Under this project, the company assumes the costs for collecting cork acorns, growing seedlings, and distributing the seedlings or acorns. Insofar as possible, all cork acorns produced are collected. After planting, the trees become the property of the planter. Efforts are made to locate all existing cork oaks, and the cork is removed from a few trees in selected areas every year for thorough testing. Specimens of soil are taken from under widely distributed cork trees for laboratory examination and classification.

The Cork Project is wholly a philanthropic enterprise. The interest and enthusiasm with which it has been received are very encouraging. Owners of mature cork oaks are cooperating by offering their trees for

experimental stripping and by donating their acorn crops. The United States Forest Service, Extension Foresters, State Departments of Forestry, Forestry Departments in the Universities, and local Agricultural Agents are cooperating with the Project. With such united effort much has been accomplished in a minimum of time. Already thousands of young cork trees have been planted from California to Florida, and the program calls for not less than a quarter of a million cork trees in 1944 and succeeding years. However, the requests for cork trees are far in excess of the number of acorns and seedlings available.

California has more cork oaks than any other state. About 4,000 trees have been located in California where they are growing in parks, along the highways, about public buildings, and on private estates. Some of these are magnificent specimens. Los Angeles County alone has more than 1,000 cork trees. A cork tree on the ground of Napa State Hospital measures 58 inches in diameter at breast height and is 75 feet tall. Scattered throughout the state there are many other large cork oaks measuring more than 40 inches in diameter.

During the past four years more than 100,000 cork seedlings have been planted in California. The cork acorns are collected during the fall and winter by the local foresters with the aid of boy scouts or members of 4–H Clubs. The acorns are packaged or bagged and shipped promptly to designated state nurseries where seedlings are grown and distributed by State Forest Rangers. The seedlings are grown by planting acorns in tall tar-paper containers that are about three inches across and twelve inches deep. They are free to any person desiring to grow cork trees, and applications are made through the local farm advisor to the Extension Forester at the University of California In Arizona 50,000 seedlings are grown annually at a nursery located near Superior. This state has about forty mature cork oaks but many of the cork acorns for planting come from California. One old cork tree in Arizona is growing at an elevation of 4,520 feet. It has many times been subjected to temperature extremes of 110 degrees in summer and zero in winter. Scattered through the southern states from Virginia to Louisiana are interesting specimens of the cork tree. Being an evergreen the cork oak is very attractive and the old trees in the South were grown for ornamental pur-



CORK OAKS, CHICO, CALIFORNIA, LARGEST GROVE IN THE U. S. PLANTED IN 1904

BRANCH OF A CORK OAK WITH PARTIALLY DEVELOPED ACORNS

poses. Twenty cork oaks have been found in Georgia and additional ones are still being located. South Carolina has about sixteen, Virginia four, North Carolina five, Alabama five, Louisiana seven, and Florida three. United States Department of Agriculture reports show that cork plantings have been made in Mississippi and Texas. Records have been found of a number of large corks that formerly grew in the south.

It is obvious that cork can be grown where healthy cork trees are now growing or have grown. Tests are being conducted to determine other sections suitable for growing cork. During the spring and fall of 1942 more than 1600 seedlings were distributed throughout the southern states from Virginia to Texas. These experimental plantings were made on various types of soils, in locations having different rainfall, drainage, and sunshine. In 1943 more than 3,100 pounds of cork acorns were distributed in the South. Some of the seedlings from these acorns were distributed last fall and others will be planted this spring. More than 4,000 pounds of cork acorns will be sent to the southern states in 1944.

An exhaustive study of soil, climate, rainfall, and temperature conditions in the United States has been made and the data compared with that of the cork producing sections of Spain and Portugal. From this study a physicogeographical map showing the potential cork producing areas in this country has been prepared to serve as a guide in planting cork trees. However, seedlings have been distributed to persons outside of this theoretical cork area, since it is entirely possible that some of the sections of our country indicated as less desirable for growing cork may produce satisfactory cork.

The quality of the cork taken from trees in selected sections is excellent. In California more than ten tons have been removed during the past four years. In 1942 more than 2,300 pounds were removed from three old cork oaks in Sonoma County. The large tree at Napa was stripped in July, 1943. Cork was removed to a height of seventeen feet and 1,050 pounds of good quality cork ob-

Paris May 6. 1786.

Your favor of Nov. 23. . . . . . . . . . . . . . . . . I expect in the same season from the South of France, some acorns of the Cork oak which I propose for your society, as I am persuaded they will succeed with you.

Wm. Drayton esq. Th: Jefferson

Paris Feb. 6. 1787.

I had the honour of addressing you . . . . . . . . . . .

the present serves to inform you that I send with it, to the care of your delegates in Congress, some acorns of the Cork oak. I am told they must not be covered above two inches deep.

Wm. Henry Drayton esq. Th: Jefferson

Dear Sir Monticello Apr. 27. 26.

It is time to think of the introduction of the school of Botany . . . . . . . . . . . . . . . . . . . . . . . . . . .

The trees I should propose would be exotics of distinguished usefulness, and accomodated to our climate. such as the Larch, Cedar of Libanus, Cork-oak . . . . . . . . . . . . . . . . . . . . . . .

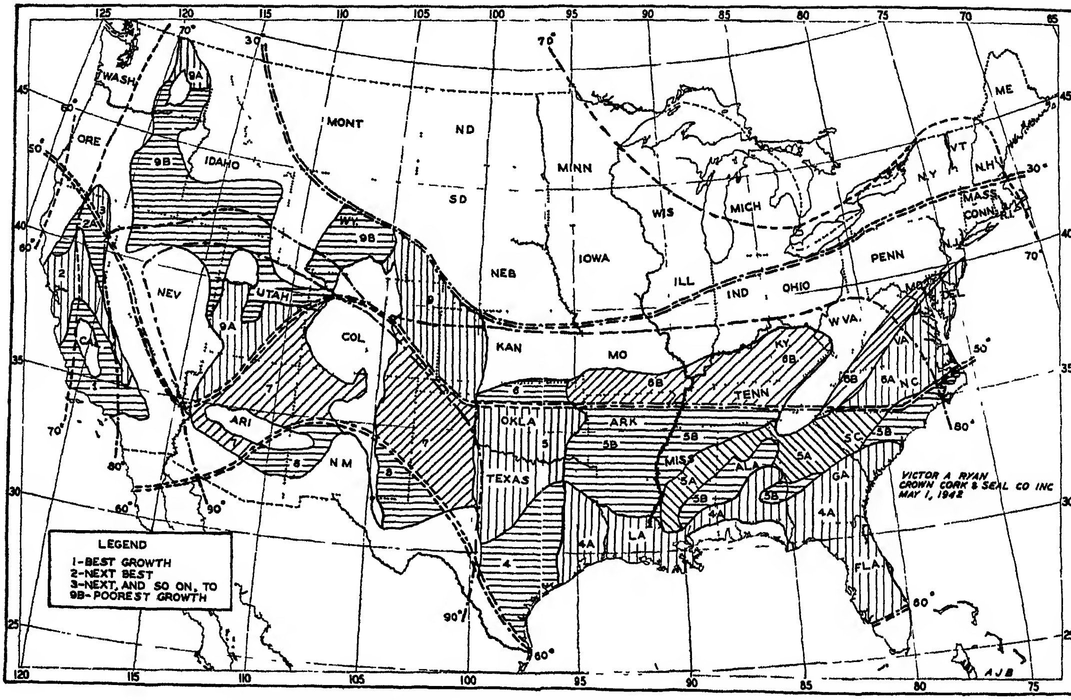
. . . . . . . . . . . . . . . . and Cork-oak, I can obtain from France.

Doctr. Emmet

Professor of Nat. Hist at the Univy. of Virginia Th: Jefferson

*Library of Congress*

LETTERS SHOWING JEFFERSON'S INTEREST IN GROWING CORK TREES IN THE U. S.




POTENTIAL CORK AREAS IN THE UNITED STATES

tained. This is the largest quantity taken from any tree in this country. Cork from southern cork oaks has been found to be of splendid quality. Stripping tests on trees eight, ten, and fifteen years old have been carried out in Georgia. Formation of the second growth of cork will be watched closely and compared with that on the large trees. Trees stripped at Chico in 1940 showed in 1943 one-half inch of new cork. On some trees the three years growth of new cork was equal in thickness to 16 years of first growth on the unstripped portion.

Along with the planting of cork trees many interesting experiments are in progress. Many of the large cork trees in the South do not bear acorns. Efforts are being made to cause these trees to fruit because the acorns are needed for planting. The trees are being given special care and scions from prolific California cork oaks have been grafted to some of them. Tests are being made on the storage of cork acorns. The best time of the year for planting varies in different areas. In those sections where the winters are cold, early spring is preferable to fall for outside planting. Cork acorns must be kept in cold storage until they are planted in order to preserve their viability. Temperatures at 36 to 38 degrees have proved successful.

Propagation by seedlings is being compared with direct acorn planting. The cork oak develops a long tap root and care must be exercised in transplanting bare root stock. The use of tall paper pots which can be placed in the ground eliminates root injury during transplanting. Direct acorn planting is desirable in many places but squirrels, gophers, and rodents destroy a high percentage unless special precautions are taken.

Special work on the rooting of cuttings is being carried out. Experiments in grafting cork to native oaks have produced interesting results. At the present time the number of cork trees planted each year is limited to the cork acorn crop. Development of successful methods for grafting the cork oak to other trees or for rooting cork cuttings would remove this restriction.

Such experiments as these require several years for completion. In the meantime, the maximum number of cork trees possible are being planted every year.

# A CRITIQUE OF MEDICAL RESEARCH*

By ALAN GREGG

IN using the term medical research, I include all research undertaken with the intent to extend our knowledge of the nature of health and disease in living tissue, and with special reference to human beings. A full list of research activities in, say, the year 1938 in ten of our larger medical schools would show so wide a range of subjects as to leave one bemused at the task of defining medical research. Nor is medical research by any means limited to medical schools: graduate work in the other university faculties may belong to the category of medical research. Meteorological studies upon the nature of cyclonic storms cannot qualify as medical research, though a study of suicides or cardiac failures as related to or influenced by weather conditions could properly be considered an outreaching branch of medical research. The study of the geographical distribution of disease, the nature of inhibition in pigs, and the relation of the *gambiae* mosquito to Crustacea carried from Africa to Brazil by airplanes are examples of the wide range of medical research. The study of tobacco mosaic has more than illumined our knowledge of animal diseases due to viruses. Though I am therefore loath to set the ambit of the term medical research, there can be no gainsaying the fact that by common usage and implication it connotes a potential, if not an actual, application of research to human health and human disease. The gamut of medical research may best be comprehended if we realize that the psychology, the biology, the physics, and the chemistry of today become tomorrow's physiology and pathology and may well become the therapy or the preventive or clinical medicine of the day after tomorrow. And, almost as often, the clinical problems of today may formulate the physiological investigation of tomorrow and pose imperious inquiries to the chemist the day after that.

Possibly the word critique is a somewhat ambitious term for my comments, yet these comments do involve comparisons with accepted standards (the characteristic of a critique), even though they are not marshalled in support of any one thesis, whether critical or explanatory.

Because there are inherent advantages in emphasizing the distinction between strategy and tactics, I had intended to group my discussion around those poles: strategy as the art of deciding when and on what one will engage his strength, and tactics as the skill, economy, promptitude, and grace with which one utilizes his strength to attain the ends chosen by strategy. Just as there can be strategy in conversation—the choice of the subject, for example—or strategy in the matter of vacation—summer, autumn, or winter, boating, fishing, or mountain climbing—there can be, and, more important, there always is, deliberately or inadvertently, a strategical element in medical research. Just as most activities can be viewed in terms of the dexterity, the smoothness, the elegance, the rapidity, the promptness, the economy with which they are graced, so medical research is open to appraisal in terms of its tactics.

I first set out to prepare a paper on the tactics as well as the strategy of medical research, but soon found that scheme too ambitious, too extensive to be covered by anything better than an index of chapter headings: such chapter headings as organization; relation to teaching; recruitment; tenure and retirement policies; the implications of support for research from the state, from industry, from foundations, from private donors; the role of money prizes, of honors and citations; publication problems both in technical journals and the lay press—one can readily see that so many subjects cluster about the tactics of research as to preclude their being included with any remarks on strategy. So I shall not discuss the tactics, the procedures, the practices and methods of medical research, but rather direct attention to the values and the purposes to be served in medical research, what is worth

* An address delivered before the American Philosophical Society on November 19, 1943, and published in full in the *Proceedings* of that Society, volume 87, number 4.

doing, when and on what we may well engage our strength—in sum, the strategy.

Most of us would agree that wisdom is rarer than cleverness, and on reflection it would, I think, be evident that the strategy of research, if not more valuable, is at least more rarely a subject of discussion than the tactics. Strategy is more demanding than tactics since strategy often must reckon with the desirability of doing nothing, or nothing at present; such intentional inactivity is often difficult since inhibition or postponement exhausts nervous energy. Furthermore, strategy, involving the knowledge of what may, and what may not, be worth doing, calls for the exercise of a sense of values, usually a more subjective and always a more mature or slowly developed sense than those accomplishments appropriate for tactical success.

Therefore, perhaps the first strategic question for medical research is this: Compared with other ways in which the time and strength of man could be spent—for example, research in government, in economics, in mathematics, or aesthetic development through poetry, music, painting, or the other arts—does medical research offer a more valuable return? The answer is not quite so obviously affirmative if we ponder on this passage from Hans Zinsser. Writing, of course, of himself, he says:

> He became, however, a profound admirer of Whitehead, who, it seemed to him, combined—in the wide horizon of his mature wisdom—deep erudition of the sciences with sensitiveness to aesthetic values, appearing in this regard to possess some of the qualities, less creative but perhaps more contemporaneously sound, of a Goethe. It was in Whitehead's diagnosis of the sick world that R.S. recognized his own, less learnedly arrived at, to the effect that, with the rapid development of industrialism and urbanization (both consequences of the scientific control of natural forces) there was a neglect of the "aesthetic qualities of the new material environment"; there was a limitation of the "moral outlook" at a time when it was most needed. The "moral pace of progress," says Whitehead, "requires a greater force of direction," but a grooved professionalism (also a consequence of the headlong rush of science) has brought it about that "the leading intellects lack balance" and "the task of coordination is left to those who lack either the force or the character to succeed in some definite career." The corrective, therefore, it seemed to R.S., should lie not in the checking of science, but rather in catching up with it.
>
> Thus, with Whitehead's assistance, R.S. thought he understood the general diagnosis. But that is as far as he got before he died. He stood before the problem as he often stood at the bedside of a dangerously sick patient, helplessly hoping for greater physicians to point a way of cure. He looked to art, literature, and criticism as the instruments through which this might come. For it seemed to him that what had happened was that mankind had been so busy planting the potatoes and corn and turnips of life that it had forgotten to tend the gardens. And now it had no gardens in the enjoyment of which it could find the reasons for which it had planted the potatoes and the turnips. For the arts and the spiritual values which they represent (and this was the pathology of the disease) had come to be regarded as trivial and not worthy of the efforts of serious men, a speculative commodity like stocks or postage stamps for rich collectors or a plaything for amateurs and eccentric incompetents; at best, a civilized amusement or a hobby.[1]

In my mentioning any challenge to medical research, you may be reminded of the advertisement in a Viennese newspaper which ran "Wanted: two hours' argument from an elderly gentleman opposed to matrimony, by a young man resolved to marry." I do not pose the primary question as to the essential worth of medical research just as a bit of target practice. The reason for asking ourselves whether medical research deserves all the time and strength it demands is simple but cogent: if we recount *why* medical research is worth-while, many of the secondary questions of what *kind* of medical research we should do will be brought into far clearer definition and perhaps into correct subordination to the larger issues.

Let us then state why medical research is worth-while.

Now the first and foremost reason for employing our strength on medical research is that to do so maintains and sustains a rational, in place of a superstitious, view of being alive—a rational interpretation of Life in its myriad forms and functions. By medical research we not merely learn important new facts, we learn a method of thinking about what is already known. By means of research we can reformulate the known, as well as master the unknown by a process of modest but relentless attrition. This rational interpretation of Nature—a heritage from the Greeks—could, I think, be shown to be infinitely precious in the chief study of man-

[1] Hans Zinsser. *As I Remember Him:* 422–423. Boston, 1940.

kind, which is man. Human conduct has never been continuously rational, and yet, when by research we finally may master all the mainsprings of behavior, we shall have a rational interpretation of human conduct even when it is irrational—in place of the passionate confusion of today.

The second reason for thinking medical research worth the strength that may be poured into it is intuitive and unanswerable: it is a property of life to defend and protect its being. Now that we can investigate disease and so control it, we shall do so in self-defense. The threat of disaster stirs our primitive emotions. By so much as a disease strikes early, it releases the protective sentiments of parents toward their children. By so much as a disease leaves the patient's character intact while moving slowly and unswervingly to death, medical research upon such disease will never lack the sympathy, the interest, the hope, and the support of those who have the double privilege of thinking and giving. Perhaps it is more than a coincidence that diseases causing changes in character, and diseases terminating in swift and unexpected death, have been the last to receive support for their study. Almost always, changes in the character of a patient affect his friends and family—their sympathies are profoundly disturbed and horror and aversion outstrip pity. In diseases where death is never seen plucking at the sleeve but is swift, unheralded, and masterful, hope, and so reflection, have not time to dispute the issue.

The third reason why medical research should receive the investment of time and strength is that the medical sciences have a right to share with other sciences the glorious freedom of curiosity implicit in the words "Pure Science." If one feels an almost sensuous pleasure in the discovery of order and natural law, he will not have to fall back on the reassurances that "curiosity pays" or such phrases as "the usefulness of useless knowledge." To be informed that Pure Science Pays, always reminds me of the early missionaries to Hawaii of whom it was said, "they went out to do good and they did very well." So precious and exhilarating an elixir of intellectual life as curiosity, I prefer to take straight, without bush or adulterant.

Because medical research tends to place the study of man on rational grounds, because it offers free range to intellectual curiosity, and because its concern with the protection of life is an axiomatic and inescapable extension of the instinct of self-preservation, we may settle the first strategic question by affirming that medical research, when compared with other types of human inquiry, solicitude, and activity, at least deserves all the attention it has thus far received, favorable as this has been of recent years.

With no further hesitation or reluctance as to value of medical research, we may turn now to the more tangible and debatable questions—when and on what research may we wisely engage our strength?

Now the first comment on the actual strategy of medical research is that it is becoming too rare an experience. This experience in selecting research projects, in estimating their possibilities and appraising their performance, has tended to become the function of persons outside the ranks of actual investigators. It is a privilege which of late has fallen to the officers of the Foundations, instead of remaining the responsibility of the investigators or the administrators of our universities. The treasurer's report for 1942 in a well-known western university showed a total of $847,000 in contributions for current purposes, of which less than $47,000 was reported as unearmarked money. With less than five percent of the research funds on which to exercise their powers of discrimination and selection, the faculty no less than the administrative officers may be expected to lose first their liberty, then their responsibility, and finally their ability to exercise judgment as to what research is worth doing. It is my personal conviction that the Foundations have established a fashion of giving earmarked funds, which has been followed by a large number of private donors, and which possesses, among obvious attractions, some serious eventual disadvantages for the recipient institutions. Principal among the disadvantages are the emphasis placed upon showmanship and expert mendicancy, the atrophy through disuse of the critical faculty, the loss of responsibility for local problems and of pride in tackling them inde-

pendently, and finally a restlessness that is second cousin to the restlessness caused by absentee ownership. So forceful a group of accusations would deserve more than the word "disadvantages" if they were all to be found always in full-blown development. They are never complete, but partial and varying in intensity. For it must be remembered that many a gift for research is a direct answer to a request for funds which was born free and untrammeled in the mind of an investigator. Nonetheless, strategical experience, that is, experience in selecting research problems and projects, is on the whole too infrequent in our medical schools, and the impact of war research contracts can naturally do nothing to offset the diminishing exercise of free choice.

The one device explicitly designed to correct the predominance of earmarked-financing of research deserves attention. It is the so-called Fluid Research Fund—a pool or account from which, under exclusively local guidance, sums are withdrawn for the support of selected research projects. I do not believe, however, that deciding how money is to be spent is research strategy. Deciding what is worth doing is strategy; having money at hand encourages the business of securing such experience in strategy. We are foolish not to distinguish money spending from research strategy. And I need hardly add that unless the discrimination and the fearlessness of the Fluid Research Fund Committee are of a singularly high order, the results in work wasted and feelings bruised will not speak for the continuation of Fluid Research Funds. No more generally useful gift than a Fluid Research Fund could be made to a medical school resolved to provide the intelligence and protect the integrity required by a fully responsible committee.

"When and on what shall we engage our strength?" runs the strategist's question. Merely to consider the question "when?" reveals the difference between two kinds of research which, like two arrows held in the hand, overlap for most of their length though they point in opposite directions. We may postpone research until there are some "good leads," some promising hunches, some encouraging suggestions that we are not far removed from a find. Or, lacking any leads or promising indications but in most urgent need of finding something somehow, we may not wait but push research forward in desperation. To the question "When shall we engage our strength in research?" one type of response waits for favorable conditions, the other cries out "Now!—We must!" Needless to say, the one form is common in peace, the other in war. I have often heard that the methods of wartime research should be applied in peace, as well as laments that the criteria of peacetime research are foregone or forgotten in war. Obviously the point of departure, the motivation, and the results of the two types of research are radically different. When war demands a specific problem be tackled, the focusing of every sort of applicable ideas and experience is called for. In peacetimes research is not so hard pressed and tends to weigh more carefully the state of current knowledge and the leads it provides, the quality of the researcher and the assistance provided him in colleagues, consultants, assistants, and equipment. The conditions of war and peace are radically different and so are the motives of research workers, but the contrast ought to be instructive. If war research in medicine can teach peacetime research anything, it probably is this: if A and B are working on problems complementary or otherwise closely related, it is a particularly wise expenditure of research funds to pay the expense of visiting each other. This is constantly done in war and all too rarely done in peacetimes. Also it seems obvious that wartime research will demonstrate the remarkable effectiveness of co-ordinated research programs, as well for medicine as for other subjects. In the rather remarkable speed with which some programs have been executed we forget that freedom from teaching has released energies otherwise exhausted in peacetime. And we forget that wartime research operates on very large financial resources and that patriotic self-sacrifice oils many a bearing that would heat up with the friction of peacetime competitiveness and jealousy.

Before naming some areas of present ignorance (and, I hope, future knowledge) which will probably receive the strategist's attention, I would like to insist that the pri-

mary and almost sacred right of choosing a subject to be studied, of framing a hypothesis to be tested, of planning and performing some crucial experiment, belongs not to the donor or the administrator, but to the investigator himself. If this privilege is not explicitly declared to be that of the investigator, the suspicion will soon sporulate that medical research should be directed from a strategical G. H. Q.—a concept so remote from my convictions and so repugnant to my taste as to call for repudiation at once.

Indeed, I have had experiences that make me wonder whether young scientists in this country feel quite as free to choose their own problems as I would like to have them feel. For a number of years I used to talk with candidates for advanced fellowships of The Rockefeller Foundation. They came from different countries and were the result of different systems of education and maturation. To the question "What do you want to do on your fellowship?" the American usually replied in terms of a problem certainly set and probably selected by his professor. This seemed so much less frequently the case with candidates of other nationalities that I came to expect it as the American answer. Was it a continuation of our national inclination to suffer children gladly, prolong adolescence patiently, and deliberately defer maturity? Or was there nothing national about it? When closer observation showed that fellowship candidates from the Middle West formed a group quite at variance with all the other Americans, the phenomenon became more interesting. The Midwestern candidates usually know what they are interested in themselves: why Midwesterners do not as frequently mirror their professors' interests as the rest of the Americans, I do not know.

If I am right in my impression that American medical research at present is not particularly hospitable to the young investigator who formulates completely fresh hypotheses in fields not familiar to his seniors, then we should find in research literature today a rather large number of instances in which the primary or germinal observation has been made by young investigators not in the United States but in other countries. After ten years abroad and ten years at home, I would be inclined to think that there are countries where more value is attached to independence and originality of thought than in this country. We Americans have been inclined to belittle the brief report of foreign literature that contains an observation and a hypothesis to fit it but lacks complete substantiation or massive proof. Sometimes I think we forget what the last war did to the strength of European laboratories, that they commonly have not been the equal of the German chemical organization. And we forget that it is by just such incomplete but fresh, independent, and pioneer observations that some of our largest, most fashionable, and most heavily laden scientific caravans are led. One should not take offense at an observation in some ways more favorable to others than to holders of American passports. In the generation before mine a number of influential American medical leaders knew and understood European medical science through study periods there. Today, I do not suppose there are four deans of American medical schools who have studied as much as two years anywhere outside of the United States. Lack of travel or foreign residence at an impressionable age makes for parochial horizons, and I think we may as well admit that we now have the elements of a continental parochialism—rendered the greater by a nationalism of an intensity rarely if ever equalled.

Another criticism would be far more worth advancing than the complaint that youngsters in American medicine practice something of the chameleon's art. The extraordinary feature of medical research in America in our times is the frequency with which demonstrated ability in research is rewarded by being extinguished. We praise research, we earnestly seek and prayerfully select young investigators of promise, we use productive scholarship and research ability as the cardinal considerations for promotion and even for the selection of professors. We speak warmly of the research career, and after all that build-up we contemplate with almost bovine placidity the professor who can't do any more research because he is too busy fulfilling the prevalent idea of a professor. The situation is not merely a diverting paradox or an academic peccadillo; it is

a stupid and wasteful abuse, committed, like many elusive futilities, in so noble a cause that its correction would seem disloyal.

It would be consoling to think that only in the earlier stages of institutional development is it necessary to sacrifice research to administration, and that once the preliminary planning has been done, men selected and trained to do research will find tradition and circumstances facilitating their natural tastes and aptitudes. But the evidence about us hardly justifies such an evasive hope.

A more common verbal exoneration of the disgrace of obliging men of unusual research ability to devote long hours to teaching and administrative work consists of saying: "Oh, if he didn't like to do administrative work, he wouldn't do it. Besides, if he was really a research man and successful at it, he would let others do the teaching and administration." The fallacy of that particular bit of gratuitous character analysis is that it does not fit the salary and promotion policy observable in all schools (and some institutes), where the assurance of tenure and the reward of salary are attached to teaching and administrative responsibilities, and not to the pursuit of research.

Persons congenitally disposed to seek for something harder and better than laissez faire will bear with me if I mention by way of remedies or solutions three procedures which in some measure at least keep research men in circumstances favorable to their best productivity.

One is the creation apart from the universities of Research Institutes or Centers for Advanced Study. Like quinine in the South Pacific, this is a pretty good remedy but there's not enough of it to go around. But even if the research institutes became quite numerous, they would still have to connect themselves somehow with universities interested in research, in the effort to be near new blood and adequate recruitment. So at long last, the importance of having research men in the universities would be recognized as important after all.

Another remedy is to create special status for research men—to call them Research Professors, or Distinguished Service Professors, and give them extra salary or freedom from large teaching loads. Though such arrangements may have worked reasonably well in some instances, they run counter to common sense in trying to devise a uniform title for exceptional men in suggesting that other kinds of professors aren't expected to do research, and in implying that many men can constantly justify so magniloquent a title and so privileged a position. Probably, however, the greatest obstacle to the establishment of research professors in distinction to just plain professors is the incomprehension of the public. "Why should a teaching institution have duplicate professors who don't teach?" is the layman's query. I believe that there we touch upon the American tradition of higher education which assumes that universities are not societies of learned men with students in attendance, but large places of instruction whose ultimate unit is not a savant but a "class" almost guaranteed "graduation" at a stipulated time.

Now the presently serious aspect about indifference to what happens to the research man when he becomes a professor is not merely the stupidity or the insincerity or the wastefulness of such procedure, but this: that by so much as institutions and men favor research and learning, they can survive social change without vital losses, but by so much as institutions and men become identified exclusively with indoctrination and teaching, they will be used by political groups. In that way lies discredit and possible disaster. The Collège de France survived the French Revolution without much change: the University of Paris was closed.

The third remedy is to maintain as adjuncts or fellows or monitors (any nondescriptive title would serve: the English employ the title "readers") a number of places equivalent to professorships, available to men of research ability but without any conspicuous title or invidious distinction of status. The chief consideration would be to maintain absolute separation, but free passage between this position and professorial status. If the reader had not a complete identity of status separate from the professor, he'd soon be no freer than a substitute; if he could never become a professor, there would be just another dead-end career in universities already quite costive enough.

The essential preoccupation of wise admin-

istration is to create and to foster the circumstances, the human relationships, in which gifted men will be most productive and prodigal of their gifts. There are those who produce best in peace, there are those who produce best under pressure. The scholar serves his interest more wisely than his comfort. And my thesis is that we need not have all professors, but some arrangements for the scholar who is not a professor—some easy-fitting title that will encourage rather than constrict. Possibly such a change would increase the professor's responsibility for being a competent expositor. In America, hiding themselves in the skirts of Research when someone begins to criticize their incapacities in speaking or writing or otherwise conveying facts and opinions, our professorial brethren condemn the art of exposition, confusing it perhaps with exhibitionism or the like.

In wartime, the selection of research projects is determined in large measure by immediate need, often by pressing emergencies. In peacetime, the selection should be and usually is decided by the imagination of the investigator, operating with the existent knowledge and techniques of his day and age. With these two factors in mind I would venture to predict a few characteristics to be expected in the medical research in the second half of the twentieth century.

We shall be investigating those factors affecting the optimum performance of the organism, not merely the infections, intoxications, and degenerative changes which reduce or destroy its functions. The distinction between sickness and health has tended with the advance of knowledge to become quantitative and gradual rather than a qualitative and abrupt difference. We have already an extensive number of tests to measure degrees of illness. An immense area awaits research upon the measurement or titration of function. Current studies of the performance of heart, lungs, and central nervous system at high altitudes illustrate this coming exploration of conditions affecting optimum functioning of organs, organ systems, and organisms.

Such studies upon external factors affecting performance will eventually and certainly direct attention to intrinsic or inherent differences between performers. So striking will be the results of early studies in individuation that a likely impetus will be given to anything explaining or even partially illuminating the remarkable uniqueness of every human being. From three quarters, besides the measurement of functions, I would expect light—the conditioned reflex studies, long-span studies of nutrition, and long-continued studies of human inheritance. Indeed, for the adequate execution of studies in human genetics we need among scientists something of the continuity as well as the abnegation of the religious order, without, I hope, any of the incalculable genetic losses inflicted on the human race by most of the celibate religious orders. Some new organization of researchers must be evolved to carry on those studies of human phenomena which require many years to complete. We have had a foretaste of such studies in the researches on child growth and development. In this field the tendency has been steadily to extend the period under which the individuals are under study. I have mentioned long-span studies of nutrition since it is evident that not merely temporary individual nutritional status deserves attention—which it is beginning to receive—but the effects of nutrition on animal colonies over periods of time adequate to establish the results of diets on genetically known stock in terms of their reproduction and survival. Probably other psychological approaches should be added to the conditioned reflexes—in order to reveal the slow and cumulative experiences by which an individual becomes unique. Certainly the medical research of the second half of this century will emphasize the function of the nervous system, from the study of the nerve impulse to psychology and psychiatry.

Surely any discussion of values in current medical research could well afford mention of subjects seemingly neglected or temporarily ignored but which might probably or desirably receive attention in the future. One is torn between the prophecy built upon conviction and the prophecy born of hope. Whether a statement belongs in the plain future indicative, the subjunctive, or the optative mood, it is hard to be sure.

In any event I should like to name a few fields for research in which the value for human life would seem to justify a great deal of effort. In the first group are subjects almost sure, under any circumstances, to be pursued in the predictable future with increasing vigor: in the second group I place subjects the strategy of whose future I would less willingly see left to chance.

The airplane and the great expansion of travel in this war and in the future will favor nosogeography—the geography of disease—and its natural corollary, the study of the relation of climate to disease and health. Let me add that there is no reason why meteorological medicine cannot enjoy the benefits of being an experimental science, with advantage to animal husbandry as well as to man. It would be natural in the light of our discoveries in nutrition and in psychology to emphasize the influence of man's surroundings, for it dawns upon an increasing number of investigators that to comprehend what man is, one must be prepared to study what he takes in from his environment and what are his external relations as well as his internal arrangements. This type of consideration will give an ecological flavor to many a research project—and the environment may be dealt with in a wide variety of terms—sociology, epidemiology, political or industrial organization, or psychological stimuli. In the light of the certainly increasing average span of human life the degenerative and the chronic diseases will receive greatly increased attention. Geriatrics may well establish its entirely logical claims to serious attention.

Among my major hopes let me record the wish that biophysics be soon recognized as the brother of biochemistry, even if the time is now too late to consider it the twin. If the last world war was in a sense fought by the chemists, this war is similarly being won by the physicists. Is there any reason for not expecting great things from establishing facilities and careers for biophysicists? One of the natural outgrowths of such a preclinical science might be the now long overdue development of physical therapy in this country. One should not conclude that I think it time for chemistry to cede place to physics. On the contrary, the development of chemotherapy in this country has called for support for the last twenty years. I should think the life insurance companies could try to regard themselves as intelligent businesses rather than timid trustees laboring in the light of stained glass windows. It would be a mark of wisdom for life insurance companies to put up funds for the support of research in chemotherapy comparable to those the food industry is putting up for research in nutrition. Think of what sulfanilamide and penicillin will save the life insurance companies in the next five years!

Of course the closest companion of first-rate chemotherapeutic research is pharmacological research. I would hope for measures leading to a substantial recruitment of first-rate talent in pharmacology and a far wider application of pharmacological methods to resolve problems throughout medicine.

The time is ripening for the application of genetics to the study of human disease and normal human physiology. As a natural concomitant of increasing knowledge of human heredity, I believe we shall see a growth in the so-called "constitutional medicine" and that facts so obtained will illumine not only disease but the innate functional capacities characteristic of different persons.

Possibly medical research will, in the next decade or two, hold up its method of thought to critical review and analysis. I find the level of interpretation of data so painfully low that, for example, I should like to hear no one attribute a condition to any cause without being obliged to specify whether he meant the cause to be understood as the predisposing, the precipitating, or the perpetuating cause. If, as Francis Peabody insisted, a scientist is known by his mental processes, I believe that explicit and detailed research on the mental processes appropriate in medicine would bring great returns to research if only in the discipline it would establish.

# THE VANISHING HAWKS

By STANLEY W. BROMLEY

One morning early in September, 1892, Davis Vinton hitched up his horse and carriage to drive over the long, dusty road that led to Oxford and the Oxford Fair. After leaving the lane and rounding the corner on the main road, he noticed something that caused him to pull up his horse and get out of the carriage to investigate. In the pasture beyond the barway and the stone wall, he saw one of his chickens, freshly-killed, lying on the ground in a welter of gore and scattered white feathers.

Going back to the house, he returned with a steel trap which he set close to the carcass after first moving it so that it was not visible from the road, and then continued his drive to the Fair. Returning at dusk that evening, he stopped to see the results of his carefully laid snare. As he approached, a large bird with one foot gripped securely in the trap rose off the ground the length of the chain. It proved to be a large red-tail hawk in adult plumage. To the best of my knowledge, this was the last authentic record of the red-tail hawk in Charlton, Massachusetts.

The red-tail hawk was the old time "Hen Hawk" of the New England farmers. Although the name was applied in response to the occasional captures of poultry by this bird, the red-tail was mainly beneficial, as it fed almost entirely on destructive rodents and insects.

The red-tail was unquestionably the "common hen hawk" recorded by Timothy Dwight, the first President of Yale University, during his travels in the late 1700's and the early 1800's. Thoreau in Concord in the 1840's took time out from his philosophical soliloquies, which have ever since charmed the reading public, to identify scientifically his "hen hawk" of the buoyant wing and superb flight as the red-tail.

The red-tail was definitely a bird of the open country. It would sit for hours on the dead top of some large isolated tree commanding a view of broad pasture or meadow land where the hawk's favorite prey of meadow mice and red squirrels or chipmunks could be easily seen and captured. This hawk shunned thick woods. For nesting, it chose a tall tree in an old open grove of oaks and chestnuts or hickories, usually on a hillside "where a wide range of view" obtained. In the eastern part of New England it usually chose an old pine in an open grove in swamp or barren sandy land.

It was a common sight, according to the early ornithologists, to see the red-tail soaring in wide circles in the upper air, the sun flashing on its white underparts and cow-red fanshaped tail, or to see it hanging on motionless wings high above its nesting grove on a steep hill, its wheezing notes of protest drifting down from above, dimmed to a sibilant whisper by the distance.

During the "teen" years of the present century, I made a series of population studies on the hawks of Charlton. At that time my ornithological Bible was Samuels' *Birds of New England* published in 1872. I was particularly bewildered by the characterization made in that book of the red-tail as "common" throughout New England. It was soon apparent to me that, forty-five years later, the red-tail not only was one of the rarest hawks in the area under observation but had entirely disappeared as a nesting bird.

Ornithologists for years have been calling attention to the dwindling of the numbers of this big hawk in southern New England. William Brewster, in writing of the Boston area in Hornaday's *Our Vanishing Wildlife* in 1913, listed the red-tail among the disappearing birds of that region, stating that he had not seen one in Middlesex County for years. Forbush, in 1927 in his epochal book, *Birds of Massachusetts,* wrote of the red-tail hawk as breeding throughout New England in the 60's and 70's wherever there was tall timber, but that it had ceased to be a common bird in the twentieth century.

In 1916 I met Mr. Calvin O. Rawson who, under the nom de plume of Jennie May Whipple, during the 70's, 80's and 90's had written so interestingly and comprehensively of the Raptores of Norwich, Conn., in the

famous bird magazine of the time, the *Ornithologist and Oologist.* Mr. Rawson had later moved to Woodstock, Conn. He then stated that there was not one red-tail in southern New England where before there had been ten.

In 1885 Rawson had written:

In my observations in the O. and O. on the Buteos of 1882, it was noted that a line drawn just outside and around this city [Norwich] would pass through the breeding places of 16 pairs of red-shouldered hawks. Now an avian atlas of this part of New London County would also show that an outer circle, girdling Norwich about 6 miles away would cut through the ancestral homes of 10 pairs of red-tails, all breeding on dry wooded uplands or hillsides.

I also met, in 1917, the Reverend C. M. Jones who used to write of the birds of Eastford, Connecticut, in the same *Ornithologist and Oologist;* he also remarked on the disappearance of the red-tail from its old haunts with the conjecture that its nesting sites had been destroyed by the cutting of the woodlands.

So the passing of the red-tail hawk from many parts of southern New England has been noted; its disappearance has become one of the ornithological ponderables along with that of the red-headed woodpecker, the dickcissel, and the purple martin, all of which vacated southern New England during the last fifty years of the nineteenth century. With the red-headed woodpecker, the cutting off of the last few remaining original oak and beech groves deprived the bird of its winter forage, while the cold, wet spring of 1904 finished the purple martin.

The last nesting record for the red-tail hawk in the Charlton area was furnished by Mr. David Stevens in 1918. During the late 80's he worked at the granite quarry located on a steep rocky hill just over the Charlton line in Dudley, Mass. On this hillside a pair of red-tail hawks had a huge nest in a tall chestnut tree. However, these woods were all cut down during the 90's and the hawks disappeared.

Here we have a clue to one of the reasons for the passing of the red-tail in certain areas. When I made my studies in Charlton from 1914 to 1920, all the old oak and chestnut woodlots had been cut down, and in their place grew thick brush and dense young woods. The red-tail hawk, deprived of its nesting requirements, had simply vanished. Even though the red-tail was probably the most persecuted of our hawks by trap and gun, it remained for the destruction of its nesting grounds to cause it to vanish completely.

There was at that time, during the "teens," a goodly complement of nesting hawks in Charlton but they were of species less affected by the changing ecological conditions. During the six years ending in 1920, I noted six species, averaging 29 pairs of nesting hawks in Charlton township—about one pair per thousand acres. In Stamford, Connecticut, I made similar studies on the nesting hawk populations from 1929 to 1939. Here I found five species, averaging 35 nesting pairs—about one pair to every 690 acres. The nesting hawks in both Charlton and Stamford were, of course, not evenly distributed but occurred where their ecological requirements were fulfilled.

A comparison of the Charlton and Stamford populations may well be noted (Table 1). In Stamford as well as in many other sections of rocky southwestern Connecticut, the lack of the red-tail hawk cannot be ascribed to scarcity of oak woodlands for nesting, although it must be admitted that there are no *open* old groves. Rather can it be correlated with the passing of agriculture and the growing up of the old pastures and meadows to brush which impedes the hunting of the red-tail hawk. The red-tail finds its food in the open. When it attempts to capture prey in the brush it gets into trouble. An incident recorded in one of the last numbers of the *Ornithologist and Oologist* de-

TABLE 1

AVERAGE NUMBER OF PAIRS OF NESTING HAWKS IN CHARLTON, MASS., AND STAMFORD, CONN.

| Species of nesting hawks | Charlton, Mass. 1914–1920 | Stamford, Conn. 1929–1939 |
|---|---|---|
| Red-shoulder | 10 | 15 |
| Broadwing | 6 | 8 |
| Sharpshin | 6 | 5 |
| Cooper | 3 | 1(?) |
| Marsh | 3 | 0 |
| Sparrow | 1 | 6 |
| Red-tail | 0 | 0 |

scribes an attempt of a red-tail, in pursuit of prey, to swoop into a thicket of brush with the result that most of its wing feathers were ripped off.

The same ecological factors in the Stamford area have militated against the cooper hawk and the marsh hawk, both of which are birds of the open country so far as their hunting habits are concerned. But the cooper hawk was a vanishing species in the "teens" in Charlton also, at a time when there was still plenty of open country.

The history of the cooper hawk—the old-fashioned "chicken hawk" of the farmers—in New England has been of great interest and has been noted by a number of ornithologists. In the early part of the 19th century this hawk was said to have been rare in New England. Nuttall and other early writers barely mentioned it. By 1872, however, Samuels had noted its increase in New England and, in 1881, Rawson stated that it was the most abundant of the Raptores. Then a decline set in and in 1927 Forbush had noted its decrease in Massachusetts. In 1913, Sage in his *The Birds of Connecticut* said that the cooper hawk "is annually becoming rarer over most of the state."

In 1915 and 1916 I questioned a number of farmers in south-central New England and the consensus of opinion was found in such statements as: "chicken hawks are getting scarce," "not nearly as common as they used to be," and "never see them anymore." The cooper hawk was the hawk most likely to catch chickens and it was presumed that these observations applied to that species.

Born on a farm specializing in the raising of poultry within seventeen miles of the Worcester, Massachusetts, market, one of my earliest recollections as a young boy was that of a hawk—which I later knew must have been a cooper—dropping out of the sky into a field near the farmhouse where young chickens were running loose, the quick clutch of talons, and the bearing away of the victim. Transfixed by the rapidity of events, I saw my grandfather rush to the scene and let drive with both barrels of a 12-gauge shotgun at the hawk mounting in circles overhead. I don't think the hawk was hit, but it did drop the chicken, which fell down on the ground almost at my feet.

Very few chickens were ever lost to hawks in the seventeen years that this poultry farm was maintained, and they were taken by cooper and sharpshins. There were farms in that area then where losses of poultry to hawks were claimed, but the figures were probably more fabulous than factual. Those were halcyon days for the cooper hawk. Many were shot at but few were hit. Most likely to be hit were the innocent and beneficial broadwing and red-shoulder hawks, neither of which I have ever known to take poultry. Both subsist largely on mice, insects, frogs, and snakes.

I recall a farmyard apple tree festooned with the bodies of three broadwings, a red-shoulder, and a sharpshin, dangling from the branches by fishlines secured to their legs. This "hangtree" with its feathered mummies dancing in the wind was supposed to be an object lesson to all hawks—a horrible example to keep them at a distance. The coopers paid not the slightest heed to that warning, but came back time and time again, usually getting a chicken at each visit.

What accounted for the decline of the cooper hawk in southern New England? Probably one factor was the decrease in land under agriculture, particularly the decline in poultry raising on the average farm. Another was the increasing precautions of the specialized poultryman who no longer let his chickens run loose where they might be picked up by hawks or other predators, but protected them by poultry wire.

A singular incident occurred on May 3, 1940, in North Stamford, Connecticut, during the height of the northward migration of hawks. A cooper hawk swooping close to the ground at a chicken in an enclosure hit full-tilt against the poultry wire and broke its neck. An examination showed that the hawk's shortsightedness was due to a blind eye which may have been diseased or injured in some avian altercation.

Starlings exhibit a particular rancor toward the cooper hawk and flock around it in flight, attacking it en masse and usually driving for the eyes of their object of torment. It is possible that a lucky blow would extinguish the sight of this member, and this may have happened to the hawk in question. However, such accidents are probably rare

and would not affect the numbers of the cooper hawk as seriously as lack of food or protection of its wild prey by the increasing amount of cover, both factors of mounting importance. The cooper's mainstay of poultry becomes more and more inaccessible while its secondary fare likewise becomes more unobtainable under present conditions.

Thus good hunting is over for the cooper hawk. It is only in areas where poultry have the run of the farmland that the hawk can catch his chicken. The cooper hawk has always specialized in game or poultry in the open. It has difficulty catching many of the native wild birds. I have seen flickers and meadowlarks elude the swoop of this hawk on several occasions. Its hunting is, moreover, made particularly difficult where the countryside is covered with thick brush and thicket growth.

The extirpation of the quail in many parts of southern New England by a combination of the cold winters of late years and the abandonment of planting small grains by the farmers has no doubt deprived the cooper hawk of another favorite item of food.

In southern New England, therefore, scarcity and unavailability of food and the presence of too much covering brush and thicket areas have produced conditions making the existence of the cooper hawk as a nesting bird precarious, if not impossible.

In a way this chicken hawk symbolizes the erstwhile marginal farmer, whose footloose and errant poultry fed the lean and hungry coopers of former years, and who was impelled by natural and economic forces beyond his control to abandon tilling the stern and rockbound soil of New England and to seek his livelihood in some other pursuit.

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## A MAN WITH A HOE

As I drew a still fresher soil about the rows with my hoe, I disturbed the ashes of unchronicled nations who in primeval years lived under these heavens, and their small implements of war and hunting were brought to the light of this modern day. They lay mingled with other natural stones, some of which bore the marks of having been burned by Indian fires, and some by the sun; and also bits of pottery and glass brought hither by the recent cultivators of the soil. When my hoe tinkled against the stones, that music echoed to the woods and the sky, and was an accompaniment to my labor which yielded an instant and immeasurable crop. It was no longer beans that I hoed, nor I that hoed beans; and I remembered with as much pity as pride, if I remembered at all, my acquaintances who had gone to the city to attend the oratorios. The night-hawk circled overhead in the sunny afternoons—for I sometimes made a day of it—like a mote in the eye, or in Heaven's eye; falling from time to time with a swoop and a sound as if the heavens were rent, torn at last to very rags and tatters, and yet a seamless cope remained: small imps that fill the air, and lay their eggs on the ground on bare sand or rocks on the tops of hills, where few have found them; graceful and slender, like ripples caught up from the pond, as leaves are raised by the wind to float in the heavens; such kindredship is in Nature. The hawk is aerial brother of the wave which he sails over and surveys, those his perfect air-inflated wings answering to the elemental unfledged pinions of the sea. Or sometimes I watched a pair of hen-hawks circling high in the sky, alternately soaring and descending, approaching and leaving one another, as if they were the embodiment of my own thoughts. Or I was attracted by the passage of wild pigeons from this wood to that, with a slight quivering winnowing sound and carrier haste; or from under a rotten stump my hoe turned up a sluggish, portentious, and outlandish spotted salamander,—a trace of Egypt and the Nile, yet our contemporary. When I paused to lean on my hoe, these sounds and sights I heard and saw anywhere in the row, a part of the inexhaustible entertainment which the country offers.

—From *Walden*, by Henry D. Thoreau

# TELEOLOGICAL ARGUMENTS

By ARCHIE J. BAHM

ARGUMENTS for the view that the world has a purpose are many and devious and based often upon curious and dubious premises. In the following, some of the more typical arguments have been selected, stated, and "refuted"—refutations consisting of criticisms typically raised against the arguments. Insofar as the case *for* the view is refuted, the case *against* the view is not thereby established. This case must be established on its own account. Arguments for the view that the world has no purpose, and criticisms of these arguments, have not been included here. As to the validity either of the arguments or of the criticisms, the reader will judge for himself.

*Design.* Familiar to all is the argument that "the world has a pattern and therefore must have a purpose." Different terms are used to express what is meant by "pattern," such as "design," "structure," "order." Usually the argument is stated so as to involve a purposer. For example, beginning with the assumption that the world has a design, the argument deduces that "there can be no design without a designer and that if a designer produced a design he must have done so for a purpose. Thus, if the world has a design, it must have a purpose."

Critics attack the argument in several ways. They say that the assumption that "the world has a design" is unwarranted. For there is also obvious disorder and lack of design which cannot be ignored in claiming that the world as a whole has a purpose, and it is possible that only our part of the world is orderly and the rest of the world which we do not know is chaotic and disorderly, and design may be merely apparent or a product of the processes of perception in human beings who are uniquely purposive and yet persist anthropomorphically in interpreting all other things as purposive.

Secondly, critics contend that the assumption that "there can be no design without a designer" is false. At least some designs are accidental. For example, ink drops folded in paper sometimes appear strikingly symmetrical. If some patterns are produced unpurposively, then it is at least possible that such patterns as the world as a whole may have have been produced unpurposively. Also, perhaps teleologists have been deceived by ambiguities of the term "design." Sometimes "design" means "intention" or "purpose," as when one asks, "What did you design to do?" Here, of course, "design" involves "purpose." But "design" also means pattern apart from purpose, as exemplified by patterns produced accidentally. Thus deduction of "intended pattern" from mere "pattern" is unwarranted.

Thirdly, critics point out that even if the world has a design and a designer, it still would not follow that "if a designer produced a design, he must have done so for a purpose." For he too might have produced the world accidentally, or he might be designing the world as a consequence of some mechanical necessity rather than as a result of purpose. Finally, even though the world was designed for a purpose in the past, there is the possibility that it now no longer has the purpose that it once had, because it may have lost its purpose, or it may have fulfilled its purpose. If so, patterns produced by previous purposiveness may remain without the patterns remaining purposeful.

Such criticisms seem not to down those who would argue from design. When attacked, they reply not so much by refuting these criticisms as by reiterating their argument in a more plausible form. The three following arguments, from analogy, from complexity, and from evolution are really variations of, or extensions of, the argument from design.

*Analogy.* "Even as a watch requires a watch-maker, a building an architect, an airplane a designer, a vessel a potter, so the world-machine requires a master-watch-maker, a master-architect, a master-designer, a master-potter. The number of obvious cases is so large that surely the argument from this analogy is warranted. Even

though it cannot be deduced that the world has a purpose, still it seems highly probable."

Critics usually grant that there is some evidence for the analogy and admit that, strictly speaking, the conclusion does have some degree of probability. But the degree is not high. For, while illustrations may be multiplied tiresomely, they nevertheless are selected examples and represent limitations of man's anthropomorphic perspective. Believers tend to see what they look for and the evidence presented represents, even though innocently, a "stacking of the cards." One might, if he tried, find even more illustrations wherein no analogous purposiveness is obvious.

Furthermore, even if the examples were selected without bias and the evidence for purposiveness of parts of the world were overwhelming, still it would not follow that the world as a whole is purposive. The argument from purposiveness of parts of the world to purposiveness of the whole world involves what logicians call the "fallacy of composition." The fallacy in the argument, "This is a bunch of large apples, therefore this is a large bunch of apples," and the fallacy in the argument, "This world is made up of purposive beings, therefore this world is purposively made up," is the same.

*Complexity.* "Even though some patterns might occur accidentally, man is too complex and intricate to have just happened. Man's chemical, physical, biological, physiological, psychological, economic, political, ethical, aesthetic, and religious interrelations all fit together in multitudes of delicate adjustments. Literary and artistic productions, governments and industries, moral codes and religious hierarchies do not just happen. Such amazing intricateness presupposes purposiveness."

Critics respond in four ways. First, complexity is relative. To anything that is relatively complex, something more simple would seem relatively simple. And to anything that is relatively simple, something more complex would seem relatively complex. The world is more complex than the minds which try to comprehend it, so the complexity of the world seems relatively complex to comparatively simple human minds. Relatively simple minds may be easily amazed. Such amazement at complexity is hardly proof of purposiveness in complexity. Secondly, the possibility that the world is one of pure chance, is made up of an infinite number of elements, and has endured or will endure for an infinite time suggests the possibility that the number and complexity of possible combinations is infinite. If, then, infinite complexity may occur from pure chance, complexity hardly presupposes purposiveness. Similarly, if the world is mechanically determined, complexity of result merely presupposes complexity of cause, rather than purposiveness. Critics contend that those who appeal to amazing complexity as proof of purpose merely reveal their ignorance of the complexity of mechanical causation. Finally, if complexity presupposes purpose, surely it presupposes complexity of purpose. It seems questionable whether any purpose or purposer could be complex enough to take into consideration all of the complexities that actually occur. How could such successive series of so many simultaneous complexities be integrated into a single purpose? One might as easily argue that the world is too complex to have been purposed as to argue that complexity presupposes purpose. Furthermore, if the purpose is at least as complex as its purposed product, what purpose could there be in duplicating the complexity?

*Evolution.* Although the idea of biological evolution was once ardently opposed by those who believed it inconsistent with the idea of world purposiveness, it is now appealed to as one of the strongest evidences of world purposiveness. "Evolution seems directed toward certain ends. Mere complexity may not presuppose purposiveness, but complexity that is going somewhere does. Evidence of direction is plentiful. Each stage of the reproductive cycle seems to serve the next stage. Each species that developed seems to have served as a basis for the development of later species. The history of biological development toward, and to, purposive man surely must have been for a purpose." Some biologists even appeal to world purposiveness for proof of the previous existence of what some call "missing links." These had to be in order to fulfill the purpose obvious in biological evolution. "Furthermore," some say, "this is a world in which the fit

survive, and since evolution has been rather consistently toward those beings which are more purposive, surely the superior success in survival of the more purposive beings argues for world purposiveness."

Critics accustomed to defending biological evolution in non-teleological terms may be somewhat taken aback by this appeal of teleologists to evolution. However, upon recovery, they contend that biological evolution has been, and for the most part still is, explained without appealing to world purpose. Thus the idea of purpose is not necessary to evolution. That evolution has direction may be admitted, but that direction always implies purpose may be refuted by pointing out that anything that goes anywhere goes in some direction. The wind blows first in one direction and then in another; but this is no evidence of change in purpose or of purposiveness of any sort. Furthermore, if evolution of species serves a purpose, why have some species developed only to become extinct? Some have developed not merely to lay the foundation for higher species in the line of development to man, but for other lines of development which eventually cease. Do some purposes end? Is it a part of the world purpose that some purposes end? Is such purpose as the world as a whole is supposed to have also endable?

Critics point out further that multitudes of simple species continue to exist, to survive, as well as complex and more purposive species. Thus, apparently, development in purposiveness is not essential to survival. Likewise, even if it be granted that more purposive beings survive better than less purposive beings, still it would not follow that such superior success in survival is for a purpose. Survival *of* purpose does not imply survival *for* a purpose. Finally, the argument illustrates human conceitedness rather than objective fact. The purpose of evolution, as thus interpreted, is to develop man, and man is the end, the completion, the perfection of the process. We accept the teleological interpretation of evolution because it glorifies man as a superior product which required so many difficult aeons of preparation. Even those who add that the purpose of the evolution of man is to serve God do so in the interest of human conceit by saying, or implying, that man is the chief object of God's attention, and the trouble God went to in planning such a complicated evolution demonstrates the greatness of God's consideration for man. But, if man could discount his own conceit, he would see that the argument for world purposiveness from evolution would have little basis.

*Value.* "Even though the previous arguments from design, analogy, complexity, and evolution fail to prove that the world has a purpose, one other additional argument does. Value or goodness exists. Many types of value or goodness exist. For example, the value of life, of hope, of love, of companionship, of beauty, of faith, of honor, of loyalty —these could not just have happened or have been mechanically caused. Literature, music, art, drama, painting, pageantry, and poetry, are more than machine-made or circumstantial products. The ecstacy of love, the sublimity of symphonic music, the peace of worship, the exaltation of success, the inspiration of faith in the future—all of these are values which could not just have happened. Life is too worth-while just to have occurred."

Critics may hedge and hesitate to explain value in non-purposive terms, but usually they hold that even though it is not necessary, yet it is possible to do so. Value consists in pleasant feeling and pleasant feeling is produced in bodies by proper stimulation or, according to at least one psychologist, when synaptic resistance to nervous impulses is decreasing. Such reduction of resistance is explainable completely by chemical and physical interpretation. Value exists in the world because those chemical combinations organized into living beings that produced pleasure survived better than non-pleasure-producing living beings. Synaptic and glandular conditions may cause objects to appear magnificent, grandiloquent, ecstatic, but such illusions merely happen to have been useful for survival rather than to be true ideas about the real world. Values exist, but exist as illusions, albeit happy and pleasurable illusions. Illusions of values may beget illusions of purposiveness, but unless these illusions also are enjoyable there is no point in being deceived by them.

Critics call attention also to the existence

of evil. Values might serve a purpose, but what good is evil? The horror, fear, hatred, anguish, pain, ugliness, nausea, and suffering of life and death are a part of the total picture. There is too much evil in the world for anyone to have planned it that way. The existence of evil is at least as much proof that the world has no purpose as is the existence of good proof that the world has a purpose. If teleologists assert that evil is mixed with the good to make it all better, critics reply that neither the observable suffering nor the common promise of eternal punishment warrant such optimism. If one has to choose between believing that the world has no purpose and believing that the world has a predominantly evil purpose, surely the former would be more desirable.

*Progress.* "Progress is possible. And progress means development toward something better or more good, toward some goal or end, toward some purpose. If there were no purpose, there could be no progress. But there is progress, therefore there must be purpose."

Critics may admit that progress is possible. But so is regress. Life can get better, and life can get worse. "The best laid schemes of mice and men gang aft agley and leave us nought but grief and pain for promised joy." Who can tell whether our present optimism about a more glorious future is justified? In the end all values may be destroyed. In the end there may be an end to both good and evil. Those who continue to be in torment and anguish say, "Let it come quickly." "Ashes to ashes and dust to dust," and between the two a period of pleasure and pain, which while we have it we should enjoy and hope happily, but when it is ended ends all for us. Purpose there may be, but progress and regress do not prove it.

*Cause.* "The world was created. If the world had not been created for a purpose, it would not have been created. For to be created or to be caused means to be caused for some reason. If there were no reason for a thing coming into being, it could not come into being. 'Reason for being' is just another name for 'cause.' But 'reason for being' also means 'purpose.' Therefore, to be caused means to be purposed."

Objection may be raised that the assumption that the world was created is highly dubious. For, it is possible that the world always existed, that it had no beginning, that it has been eternally. Or, if it did not exist eternally, then whatever caused it to exist either existed eternally or was caused by something which either existed or was caused by something which existed eternally, and so on. Thus, either the premise, "the world was created," is false, and thus the conclusion does not follow, or the difficulties which one seeks to avoid by postulating creation are simply pushed back to that which did the creating. If the latter be granted, that is, that the world was created, then was that which created the world itself created? If not, then it had no creator and thus no reason for being. Thus there would be an uncaused and unpurposed creator of the world. But if so, the creator of the world must, by the same argument, have been created for a purpose; and the creator of this creator either must have been created for a purpose or have existed eternally unpurposed. Thus purpose must have arisen somehow without being caused or purposed by some ultimate purpose. And even if there were an endless series of creative purposes, one might still ask, "Was the series as a whole purposed?"

Definition of "cause" as meaning the same as "reason for being" begs a question which critics will not admit. Causes are "necessary and sufficient conditions," not "reasons." "Reason for being" is a loose popular expression developed in a background which was saturated with human purposiveness. Neither looseness and ambiguousness of popular usage nor question-begging presupposition of purposiveness can be admitted as proof of world purposiveness. "To be caused" does not mean "to be purposed."

*Authority.* Except for appeal to design, probably the most common argument is appeal to authority. Especially those who have tried to argue, and seem to themselves to fail, appeal to authority, which sometimes seems to be above argument. Authorities of many kinds are appealed to—eminent men, the Bible, the Church, Jesus, God. This type of argument may be illustrated by the appeal to the authority of God. "God, through

revelation, has said that the world has a purpose, and what God says is so, is so."

Critics are expected to cringe before this appeal to the authority of God himself, yet in fact they seldom do. They rebut as follows: Is there a God? One first has to prove that God exists before he can claim that God is an authority. One of the commonest arguments for the existence of God is the argument from world purposiveness: "The world has a purpose, therefore the world must have a purposer, namely, God." However, such an argument presupposes that the world has a purpose, whereas the present argument for world purposiveness presupposes the existence of God. Using both of these arguments would be to commit the fallacy of "reasoning in a circle." Thus, unless one can find some other proofs of God's existence or can get his critic to grant it, he will be unable to prove his case. But even granting that God exists, it does not follow that the world has a purpose, because God might have created the world accidentally, or have created the world as a result of mechanical necessity, or have created the world in the past for a purpose which he has now forgotten. Furthermore, still granting that God exists, does it follow that God is an authority? God might exist without being a person, or without being actively interested in the world (as Deists claim), or without being interested in acting authoritatively. However, granting both God's existence and authoritativeness, did God ever say that the world has a purpose? All alleged reports of God's speaking to persons in such a way that one might infer that the world has a purpose are dubious. Someone has questioned every one of them. Furthermore, all those who appeal, not to the writings of historical revelators, but to their own experience in communion with God and of his revelation directly to them that the world does have a purpose have been accused of self-hypnosis and self-deception. Also, evidence may be presented for God's non-authoritativeness. For example, there are contradictions among contentions of different revelators and most revelators contradict themselves sooner or later. Such contradictions prove that God was not involved, because God is always consistent.

*Self-contradiction by mechanists.* "Those who claim that nothing has a purpose do so for a purpose, and thereby contradict themselves. The very laws of mechanics used as a basis for explaining the behavior of things non-purposively were formulated by human minds for a purpose. Mechanists would be the first to discard those mechanical laws which were not suited to their purposes."

Mechanists reply that the claimed contradiction is only an apparent one, not a real one. For mechanists explain purpose in non-purposive, or mechanical, terms. Purpose is a notion in a causally (non-purposively) determined mind. Even if the mechanist seems to those who interpret things purposively to be acting purposively, he claims that such purposes are mechanically caused. Thus he involves no contradiction.

*Proof by mechanists.* "Since every normal person seems to himself at times to act for a purpose, everyone must admit that there are at least human purposes in the world. If, as mechanists claim, the world is uniform, then if there is purpose in part of it, why not also in all of it? Furthermore, since, for the mechanists, nothing can occur spontaneously but everything must have a cause that is capable of causing it, purposes which do exist must have been caused, and in order for them to have been caused there must have existed in the world other prior purposes capable of causing them. These prior purposes must have been caused by still earlier purposes, either backward infinitely or by some first or ultimate purpose. Thus mechanism really presupposes world purposiveness."

Mechanists may grant that personal purposes constitute a part of the world, but maintain that it does not follow that the whole world is made up of personal purposes nor that the world as a whole has a purpose. "Uniformity of nature" does not mean that everything is alike, but only that when a given set of causal conditions recurs there will result an exactly similar set of effects. Arguments from parts to whole are unwarranted, as can be seen from the example of a worm in a partly rotten apple. If he is in the rotten part, it may seem all rotten. If he is in the good part, it may seem all good. If he is on a border between the two, it may seem either a good apple with a rotten part

or a rotten apple with a good part. One might just as easily argue for non-purposiveness of the whole world on similar grounds, for everyone will admit also that some experiences seem lacking in purpose.

*Unprovability of mechanism.* "Since human knowledge is limited and since there is much about the universe that we can never know, mechanists can never prove conclusively that the world has no purpose. For even if it were provable that everything in the known universe is non-purposive, it still would not follow that the rest of the universe which we do not know is non-purposive. So long as complete mechanism is unprovable, it is reasonable to suppose that teleology is true."

Mechanists reply with almost exactly the same argument. "Since human knowledge is limited and there is a part of the world which we shall never know, even if it could be demonstrated that everything in the part of the world which we do know is purposive, it still would not follow either that the rest of the world is purposive or that the world as a whole has a purpose."

*Universal agreement.* "People of all times and places have believed that the world is purposive. Except for a few oddities, everyone believes that the world has a purpose. Can such a great majority be in error?"

Normal rejoinder is that popular agreement is no safe proof of truth of any belief. For thousands of years people agreed falsely that the earth is flat. Likewise, all people naturally believe that color exists in things independently of persons who see it; yet scientists tell us that color as experienced is not really out there, even though naturally we must continue to act as if it were. Such illusion is convenient, useful, natural, and universal, but not for those reasons true. Popular consensus is indicative not so much of cosmic teleology as of anthropomorphic teleology. People believe that the world is purposive, not because the world as a whole has a purpose, but because people are purposive and tend to interpret other things as if they were like people. This accounts for universal agreement about world purposiveness at least as adequately as does the theory that the world as a whole has a purpose. Furthermore, who knows what the popular consensus is? No poll of opinion on this question has ever been taken. No one can say with certainty that everyone does believe that the world has a purpose, certainly not with regard to those of the past who can no longer be polled, nor those of the future not yet pollable.

*Pragmatism.* Many pragmatists define truth thus: "Those beliefs which work successfully, which are useful in adjusting ourselves to our environment or in solving our problems, are true. And those beliefs which work most successfully are most true." Teleologists who accept this pragmatic definition of truth say, "The belief that the world has a purpose works successfully and therefore is true. Furthermore, people who have faith in world purposiveness get along better and are happier than those who do not. Thus, it works more successfully and thus is more true."

"But," say mechanists, "such success of teleologists is due to the fact that they haven't yet tried to use their belief in areas where it won't work so successfully. Everyone has some ideas which work well for a while or in certain areas, but which have to be given up when used in wider areas or over a longer period of time. Teleologists are simply less-experienced than the mechanists." Using exactly the same definition of truth, some mechanists seek to "turn the tables" by saying that the belief in mechanism works better than the belief in teleology. Appeal is made to the comparative adequacies of the teleological and mechanistic hypotheses in promoting scientific progress. Mechanists claim that most science presupposes mechanism and the progress of science stands as testimony of the superior success of the mechanistic hypothesis. The history of scientific progress is a succession of stories in which belief in mysterious purposes was given up for belief in the reign of natural law. Relative backwardness of the social and political sciences is accounted for because they deal with areas in which people are least willing to give up their illusions about cosmic teleology and accept the more useful mechanistic hypothesis. If the pragmatic test proves anything, they claim, it proves that mechanism is more true.

# FRANCISCO HERNÁNDEZ: NATURALIST, 1515–1578

By VICTOR W. VON HAGEN

WITHIN fifty years after the discovery of the New World, the conquest of the Americas was complete. Native resistance had been annihilated. The civilizations of the Aztecs, the Chibchas, and the Incas were reduced sufficiently so that organization could take place. In order to make the new territory easier to administer, the Spanish Crown decreed that the peoples of these vast lands with all their varied customs should be studied and that the native plants and animals should be thoroughly investigated. Henceforth every ship that left Spain carried its historiographers, notaries, lawyers, and eventually natural philosophers, among whom was Francisco Hernández.

Hernández, it was true, had been preceded by others, notably Gonzalo Fernández de Oviedo. As warden of Castillo de Oro, now the territory of Northern Panama, Oviedo had gathered together a wealth of information. But he told too much. The Council of the Indies, who guided the destinies of the New World, was adamant on this point. Because of this, only a fraction of Oviedo's travels and inquiries became known, and his reports whetted, without satisfying, the appetites of knowledge-starved Europeans. Still, Oviedo's work, despite its emasculation, served its purpose, for it aroused the interest of Francisco Hernández, who was to become our first American naturalist.

A native of Toledo, a graduate of medicine from the University of Salamanca, and then, by the grace of his curing talents, Physician-in-Ordinary to Philip II, Hernández became obsessed with the desire to conduct an expedition to *Nueva España*, and there, after exploration, to prepare a complete natural history of the country, including a catalogue of its plants and animals, a history of its ancient culture, and a detailed map of the whole province. Hernández did not allow his desire to remain dormant; he daily besieged his royal patient, Philip, with projects, plans, and charts. At last the King of Spain was convinced. Hernández would lead such an expedition, and it would be financed by his royal purse. Thus in the spring of 1570 the first government-sponsored scientific expedition set out from the Kingdom of Spain.

For five years Hernández and his expedition moved through the length and breadth of Mexico. From the lush lowlands of Vera Cruz and Tabasco to the verdure-splashed hills of Puebla, Morelos, and Guerrero, they picked their way. They traversed superbly cultivated valleys and tramped in primeval jungles. Hernández noted the fine, shapely natives, "who, were they dressed and kept from the sun and air, would be almost as white as in Spain." Yet, most of all, this medico-naturalist was impressed and enchanted by the great varieties of plants and the never-ending parade of birds, from the diminutive hummingbird to the ridiculous-beaked toucan.

Hernández' Mexico was an ancient land which, despite its rape by Cortés and his myrmidons, still kept to its age-old folkways. The Indians were docile, without being, as yet, subservient. They remembered their past and their traditions, and served Hernández well. He was generously supplied with native interpreters and artists; and also with collectors and naturalists, for Montezuma had kept a large aviary.

Hernández traveled everywhere. All the important animals of New Spain were described by him and figured by his artists: the *jabali* or wild pig, the jaguar, the armadillo, chameleons, the hairless Chihuahua, the California horned toad, and even a North American bison. But his most important work was done on the botany of Mexico.

Hernández divided the plant kingdom of the Aztec into two great natural orders, the woody (*quauh*) and the herbaceous (*xiuh*), and subdivided these plants and trees into four great artificial classes according to their uses: the edible, the medicinal, the ornamental, and the economic. Hernández collected medicinal plants assiduously and gave them the greatest attention. He was careful to note from his Aztec interpreters whether a plant was used as a pectoral, stomachic,

diuretic, emollient, or soporific—and where knowledge was lacking, Hernández made himself the guinea-pig. In Michoacan, he purposely swallowed some latex of the plant known as *Chupri* (identified later as a species of the genus Euphorbia, the deadly spurge). For months he lingered miserably between life and death. Then the work went on.

The real value of his subsequent thesaurus resulted from Hernández' recognition of the value of his Indian collaborators. All his information came from these skilled informants, who knew the native plants and their characters, synonymy, and classification—all of which Hernández put into his notes. As he confesses in his thesaurus, they made his great work possible. Native artists illustrated each plant that Hernández collected, and these drawings, with the descriptions of the collected plants, became the basis for his thesaurus. The first eight books or chapters of the volume that was finally published were devoted to botany. His thesaurus is to be regarded as a mammoth ethnobotanical herbal on Dioscoridian lines.

In five years he had filled sixteen folio volumes. In 1576, in the sixth year of his expedition, he retired permanently to Mexico City to undertake the final compilation of his work, preparatory, so he thought, to its publication. But there were several unavoidable difficulties. He encountered the hostility of other Spanish physicians in the provinces and, what was worse, Philip of Spain, who had sent him hither, had failed to give him the needed and promised financial support. Resourcefully, Dr. Hernández went into private medical practice in Mexico to repair his financial bastions. He spent some months at the Indians' *Hospitial Real* where, with the renowned Alonso Lopéz de Hinojoso, he made a special study of a local disease, *cocolixtli*, inspecting many corpses to discover the origin of the disease and a remedy for it. There his patients had the privilege of receiving treatments from the hand of a man who had once prescribed for the august person of a king. By these means, Hernández earned enough to carry on his work.

Up to this time Philip II had done little for the expedition; he had had other worries. Drake and Hawkins were loose on the Spanish Main, in Peru the Incas were in revolt, and a costly campaign by his Armada was planned against the island-kingdom of Queen Elizabeth. However, so impressed was Philip by reports of this stupendous and heroic work of Francisco Hernández that he squeezed 60,000 ducats out of the Spanish treasury for its completion. That sum, unfortunately, was hardly enough. Interpreters, native collectors, artists, wood-block craftsmen, and reams of fine imported linen paper for these sixteen folio volumes ran high.

With the aid of his son, who had accompanied him, he completed, in September, 1577, the sixteen folio volumes which were to form his great work. The thesaurus, which had first been written in Latin, had been put into Spanish, and from the Spanish into the dominant Indian tongue—Nahuatl.

Immediately after the work was done, he left for Spain. Aboard ship he busied himself in compiling a budget of costs for the proposed publication. He even arranged guides for the illustrations, which he had planned to have executed in color. Only a few colored notes of these are extant; but from them one can grasp the excellence and the completeness of this first great work on American natural history.

Arriving in Madrid, he was treated to his first disillusionment! The great work with all its woodcuts, its ethnobotany, its map of New Spain, its wealth of medicinal information was not printed, but instead the folio volumes were exquisitely bound in tooled leather and then were buried in the stacks of the library of the Escorial. This perfidy was a horrible, bitter blow to Hernández. He had no reason to appreciate the "honor" given his manuscripts by interring them in a hallowed place in the Escorial even though, as one contemporary remarks, the manuscripts were "superbly bound in blue morocco, tooled in gold and with locks, clasps and corners—all of high wrought silver." Hernández never recovered from what he regarded as an act of extreme analphabetism. He was now past sixty. His health, already seriously undermined by the privations occasioned by his explorations, was failing, and his earthly dreams were shattered. He had set out to do that which his predecessor, Oviedo, had failed to do—to

give a scientist's view of the New World. He had done his work, but the publication of it was suppressed. Hernández had no heart to go on. Worn out by the penalties involved in his researches, he died a year after his return from Mexico.

Then, some years after his death, as if the gods had planned a sardonic jest, the attention of Philip II was again called to the work of Hernández. Having decided to print it, the King called in Nardo Antonio Reccho and set him to editing the work. Under his commission Reccho was to "extract" the most useful and important parts of the manuscript. Reccho interpreted his instructions as referring chiefly to those parts that dealt with medical information. Thus was lost the completeness of the Hernández text. Yet, had not Reccho undertaken the work and carried back to Naples much of the material for the publication, we should have been infinitely the poorer, since the original sixteen folios of Hernández (along with many another classical report on America) were destroyed in the conflagration that consumed the Escorial in 1671.

After having abridged Hernández' work and prepared it for the printer, Reccho died. The work was willed to Reccho's nephew who brought it to the attention of a great patron of letters, Prince Frederico Cesi, Duke of Agua Sparta, a patron of science and founder-president of the Lyceum-Museum of Natural History. The Prince acquired it at no little expense to himself. Being a man of keen perception and enthusiasm, he commissioned artists to obtain from the archives additional illustrations from the Hernández manuscript. The Prince himself assumed the task of executive editor.

It was not until 1612 that parts of the thesaurus were distributed among specialists for new editing, arranging, and annotating. Prince Frederico wrote a remarkable epilogue for the proposed edition—an essay entitled "*Theatri Naturalis Phytosophicae Tabulae.*" This vague, rambling exposition takes up a large part of the printed work. By 1628 the manuscript was ready for the press. Doubtless Prince Frederico intended to defray the costs of publication, but again death intervened. The Prince left to the Lyceum, as a sacred legacy, the printing of the Hernández' work, but, unfortunately, he left no money to accomplish it. Ultimately one of the members, Francesco Stelluti, sought out the Spanish Ambassador to Rome, don Alfonso Turiano, and from him obtained the money to publish the manscript.

Thus, in the year 1651, what was left of the great thesaurus of Francisco Hernández, the first American naturalist, was finally printed in Rome in one monstrous volume of nine hundred and fifty pages.

# PRECIPITATION REGIONS IN THE UNITED STATES

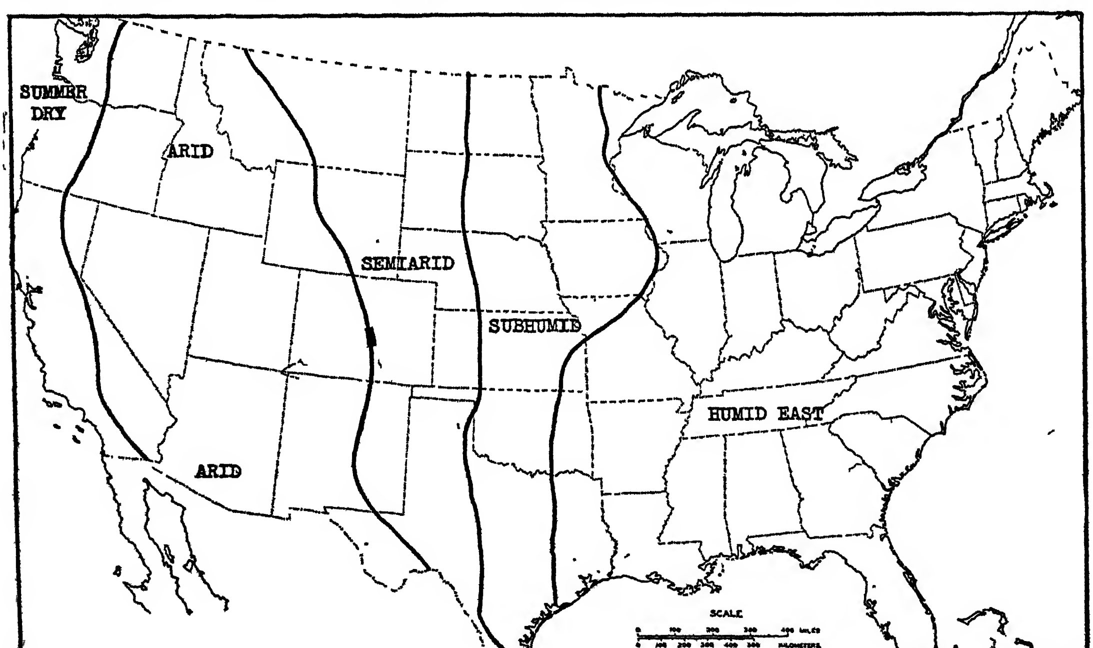
By STEPHEN S. VISHER

GREAT differences within the United States in precipitation, both average annual and seasonal, have encouraged the recognition of precipitation regions. The commonly recognized regions are the humid, subhumid, semiarid, and arid. Areas with an average annual precipitation in excess of 30 inches are called humid, those which normally receive less than about 10 inches are called arid, areas with averages of 10 to 20 inches are frequently classed as semiarid, while those receiving from 20 to 30 inches are sometimes called subhumid.

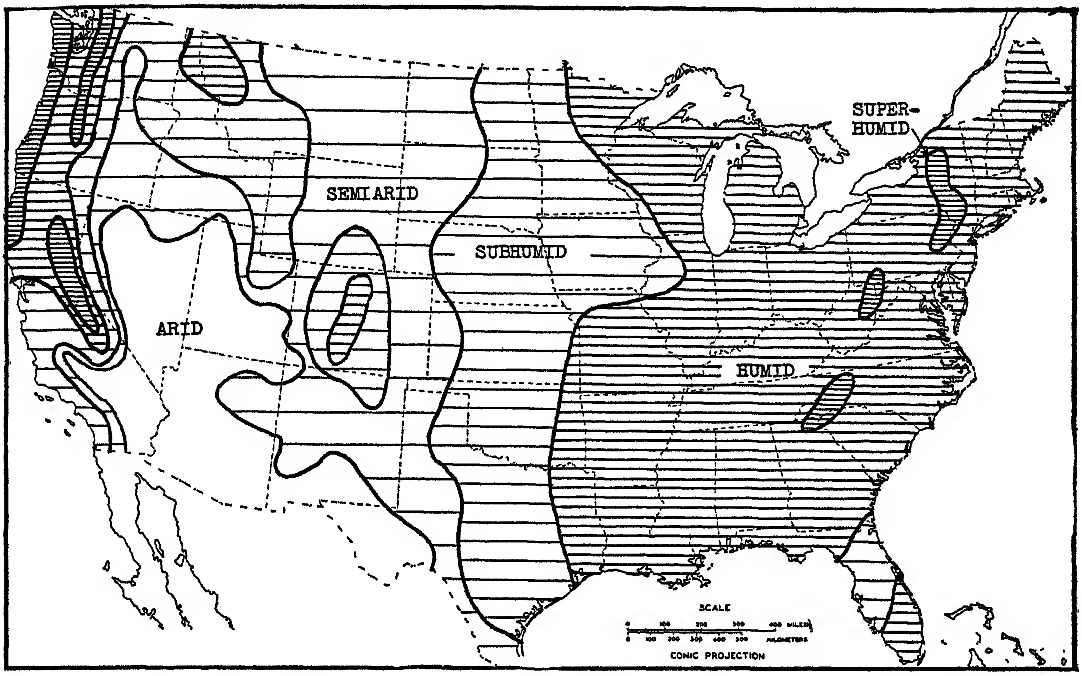
The first two of the accompanying maps show the regions recently recognized by officials of the United States Department of Agriculture. Map 1 is assembled from the locational maps for the chapters in which each of these regions is discussed in the 1941 Yearbook of the Department of Agriculture, *Climate and Man.* Map 2 is a simplified shaded copy of the average annual precipitation-effectiveness map of the "Atlas of Climatic Types 1900–1939," prepared under the direction of C. Warren Thornthwaite.

Maps 1 and 2 reveal interesting differences. In Map 2 parts of Florida and Illinois are classed as subhumid rather than humid, but much less of the West is classed as arid than in Map 1. Moreover, Map 1 does not subdivide the Pacific Coast region as does Map 2. Finally, Map 2 recognizes that parts of the humid region are superhumid.

Factors responsible for differences in precipitation in the major regions shown by these maps are: (1) the position of the United States with respect to the great wind belts; (2) its topography, especially the western mountains and the Mississippi Basin; (3) the presence of many cyclonic disturbances. Significant also is (4) the fact that the United States is part of a large continent which heats up notably in summer but becomes relatively cold in winter. The prevailing westerly winds carry much moisture from the Pacific Ocean onto the western




MAP 1. FIVE PRECIPITATION REGIONS




MAP 2. NORMAL ANNUAL PRECIPITATION-EFFECTIVENESS

coast, but because of the lofty western mountains, little or none of it reaches the central part of the country. The section east of the Rockies obtains most of its moisture from the Gulf of Mexico, drawn northward by winds blowing into cyclonic disturbances. The center of a disturbance moves rather rapidly eastward across the country. Because the wind moves in counterclockwise direction, the moisture that it carries moves into the country on the eastern arc of its center of rotation. Since precipitation of moisture from these winds declines with distance from the Gulf, it follows that average precipitation increases eastward from the Rockies.

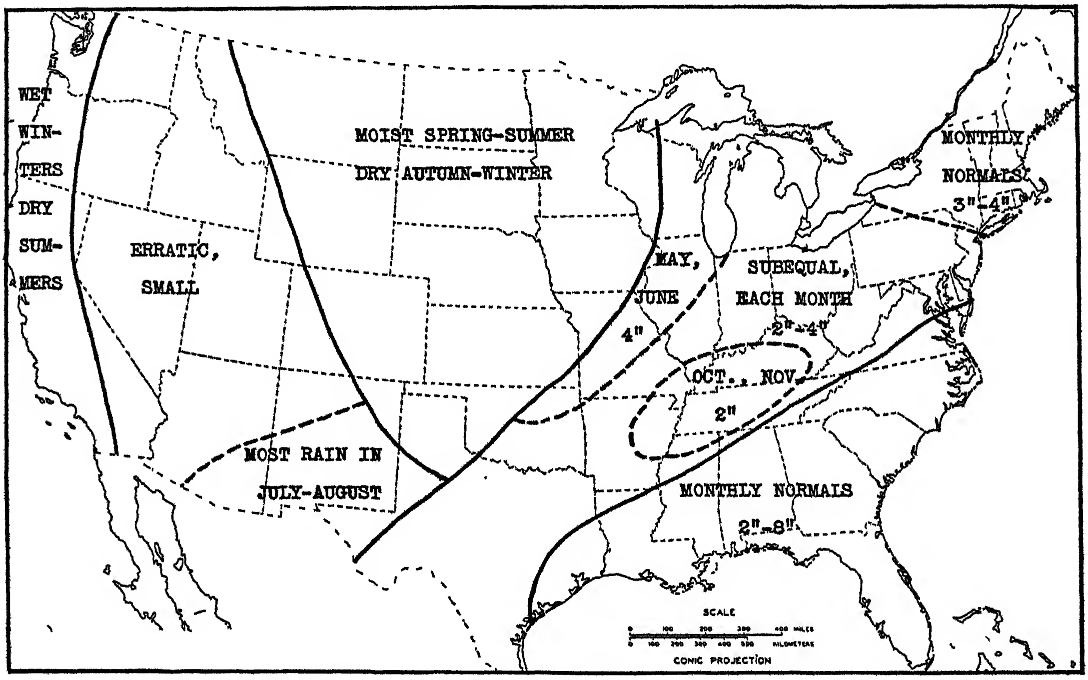
The cyclonic disturbances which affect the United States are of two chief sorts: the so-called mid-latitude Lows and Highs, and the tropical cyclones. The Lows cross the country from west to east, more of them traveling across the northern half than across the southern half. Tropical cyclones enter from the south, or pass northward near the eastern coast, many of them bringing large amounts of rain. Some move slowly in parts of their course; a few of them have such violent winds as to be called hurricanes. Nearly all that enter the country soon lose most of their moisture, thus helping to explain the northward decline in average precipitation in the central and eastern part of the country. A more important cause of this northward decline is temperature drop from sea to land, as in winter, condensing wind-borne moisture before it is carried far over the land.

As to seasonal distribution, five precipitation regions are here recognized (Map 3): (1) a large region extending from Maine to Texas, which normally receives approximately equal average amounts of precipitation in all months (2 to 4 inches); (2) a southeastern region, where the monthly totals range from 2 to 8 inches—thus some months are much wetter than others, but none is normally dry; (3) the Pacific Coast region, where the summers are almost rainless and the winters are wet; (4) a large central region, especially the northern and central Great Plains and Prairie region, where the winters are relatively dry and the spring and summers normally are moderately rainy; and (5) a large western region, often called the arid region, where the precipitation is generally small and is always highly erratic, sometimes occurring chiefly during the cooler months, sometimes during the warmer ones, and sometimes in neither.

The approximate boundaries of these five

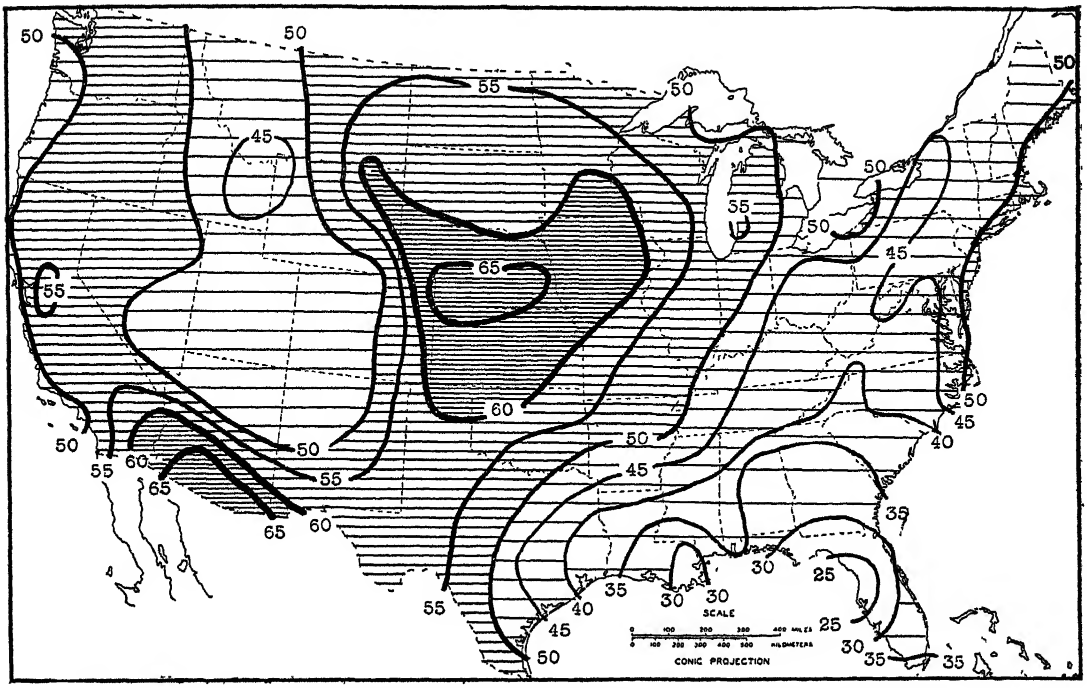
regions are shown in Map 3, which is original, although based partly on data assembled by Kincer in the precipitation section of the *Atlas of American Agriculture*. As indicated in Map 3, subdivisions of some of the regions are recognizable. In the 2- to 4-inch region, for example, New England and New York receive the most uniform precipitation, normally from 3 to 4 inches each month. Near the western margin of the same region, May and June are the rainiest months and winter is driest, whereas in an area centering in Tennessee, spring is wettest and autumn is relatively dry. The arid region also has an interesting subregion near the Mexican border where rainfall is least rare in July and August. These occasional summer rains in the Southwest help to explain the presence of the cliff dwellers, who depended largely on corn. In most of the arid region, corn was little grown by the Indians, partly because there was little midsummer rain. In the large southeastern coastal region the wettest months differ locally, but on the average come in late summer or autumn.

The causes of the regional differences in the seasonal distribution of precipitation are largely results of seasonal contrasts in continental heating and cooling. The continental interior is relatively cold in winter, when winds do not often bring moisture deep into the interior. In summer, on the other hand, the interior is relatively warm, and moisture-bearing winds reach the interior much more frequently. On the average, moreover, the Lows cross the continent in higher latitudes in summer than in winter. The precipitation uniformity of the Northeast results from its numerous cyclonic storms and its location between nearby large water surfaces, the Atlantic and the Great Lakes. As many Lows move across the Lakes and along the St. Lawrence Valley throughout the year, moisture-condensing Lows are sufficiently frequent and intense even during the winter to prevent dryness in New England. The Great Lakes help to intensify the Lows, as well as yield winter moisture. The southeastern part of the United States has fewer ordinary Lows, but has more tropical cyclones which are most common in late summer and autumn; then they often yield rains heavy enough to pull the average monthly totals far above those generally attained in New England. The Pacific Coast is dry because the cool sea breezes, warmed by the land, retain their moisture.



MAP 3. REGIONS OF DIFFERENT SEASONAL PRECIPITATION

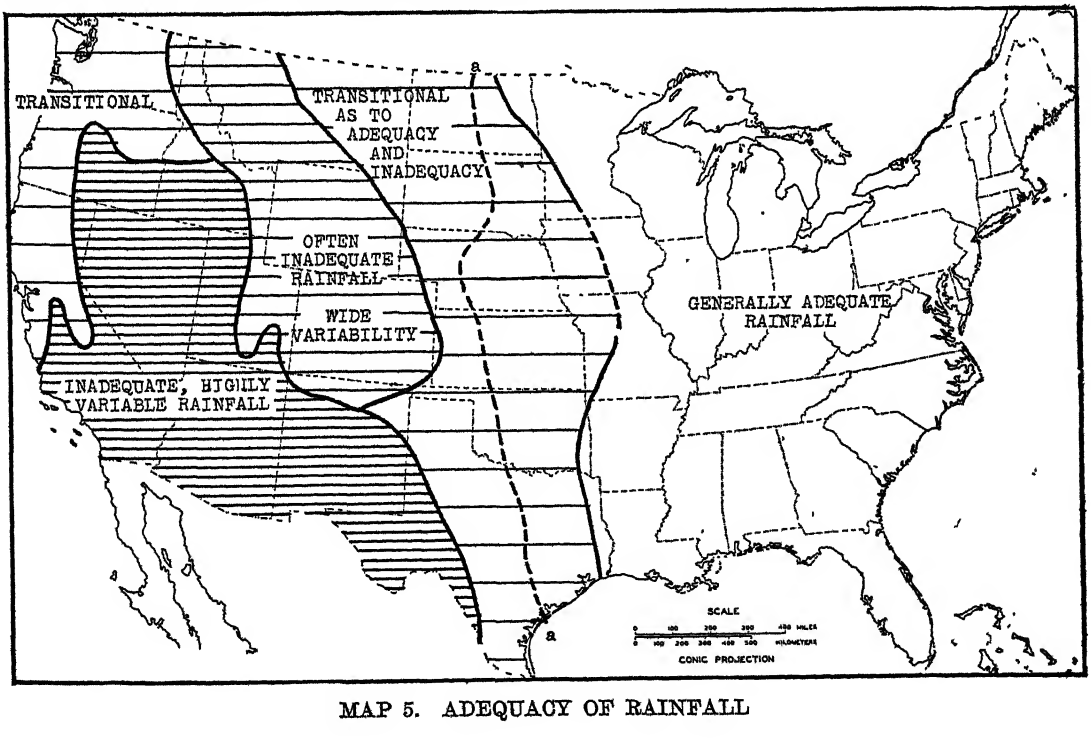
Three other sorts of regionalization on the




MAP 4. PERCENT OF WARM-SEASON RAIN FALLING AT NIGHT

basis of precipitation have been attempted for the United States: (1) the percentage of the precipitation falling at night; (2) the dependability or reliability of precipitation; and (3) the intensity or torrential character of the rainfall. The regional contrasts in these respects are presented in Maps 4–7.

Map 4 shows the percentage of rain falling

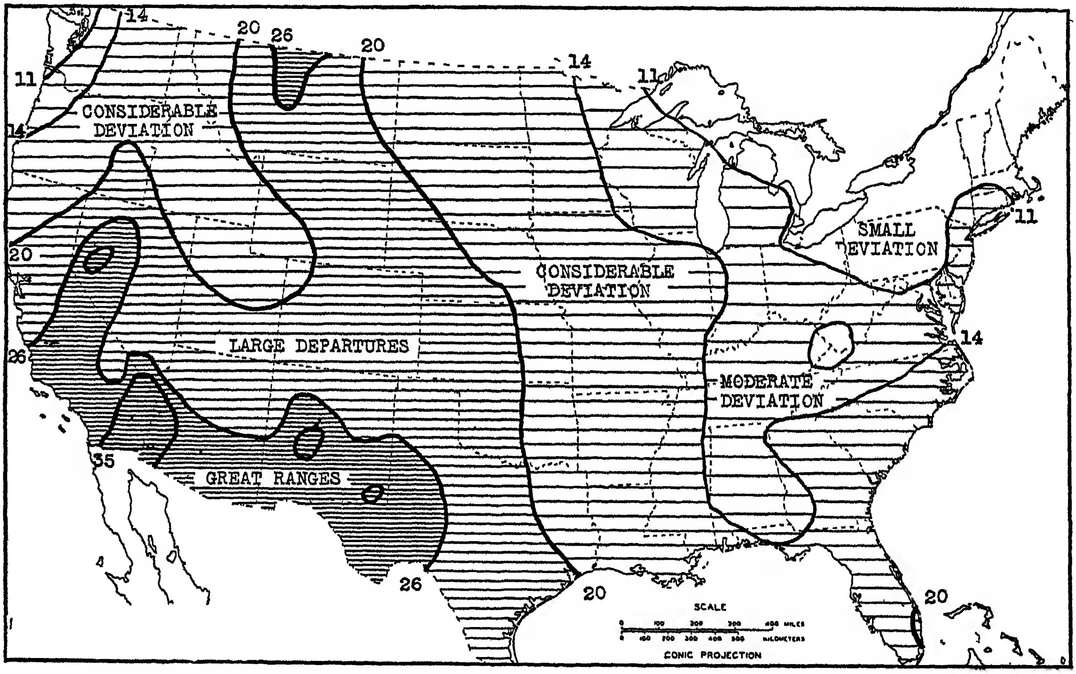



MAP 5. ADEQUACY OF RAINFALL

during twelve hours including the night (8 P.M. to 8 A.M. E.S.T.) from April to September inclusive. It is redrawn and shaded from a map by Kincer in the *Atlas of American Agriculture.* It shows that a much larger proportion of the warm season rainfall comes at night in the center of the country than in Florida. The percentage is higher in Arizona than in Idaho, reflecting greater evaporation, while falling, of daytime showers in Arizona.

Map 5 is redrawn from one by Isaiah Bowman in the 1935 Report of the Science Advisory Board (line a – – a indicates the eastern limit of "Occasional Desert Years"). Florida having as much variation as North Dakota.

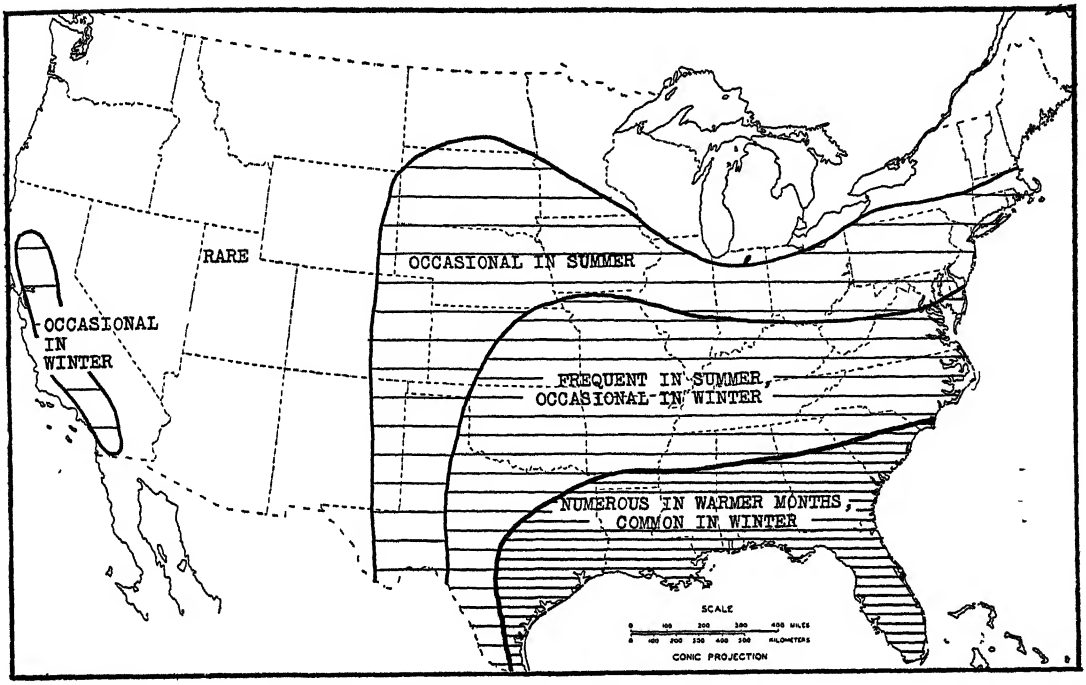
Map 7 is an original one based on scores of maps in D. L. Yarnell's "Rainfall Intensity-Frequency Data," U. S. Department of Agriculture, 1935, and on more than a dozen maps made by combining part of his maps, to discover the frequency (times per decade or century) of rains of various magnitudes. Also used were original maps of very heavy rainfalls which were published in the *Geographical Review* and in the *Monthly Weather Review.* The definitions of "very hard rains" and of "numerous" and "rare" are as follows: Very hard rains are those which yield 2 inches of water within 30 minutes, or 3 inches in an hour, or 4 inches in 8 hours, or 5 inches in 16 hours, or 6 inches or more in 24 hours. Numerous means that there were 5 or more very hard rains per year. Rare means that there was only one rain of any of these 5 magnitudes during an average decade or longer. In parts of the North and West, no such rain was officially recorded at the many Weather Bureau stations in the thirty years studied. This map shows marked changes with latitude in the East, but none in the West.




MAP 6. PERCENT DEVIATION FROM THE MEAN ANNUAL PRECIPITATION

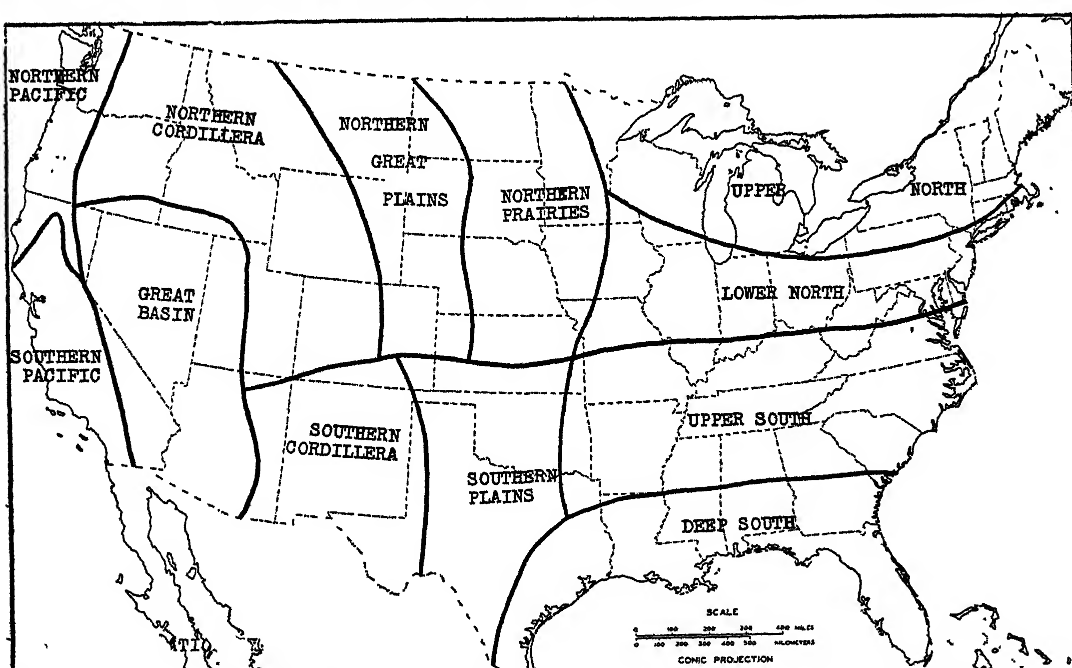
This map shows five great regions. Perhaps its most interesting feature is the classification of the Northwest as transitional, although, unlike the transitional Great Plains, it is the region of greatest annual average rainfall.

Map 6 is a redrawing (simplified and shaded) of a map of the annual deviation from the mean annual precipitation in the 1936 Report of the Water Resources Section of the National Resources Board. This map shows considerable regional contrast in the East, the North having least variation, but




MAP 7. FREQUENCY OF VERY HARD RAINS

Map 8 is a sort of summary or composite of the foregoing maps and several others. In its preparation special attention was given to the amount of rain falling in short periods and to the frequency of torrential rains of various magnitudes. Consequently, the northern and southern parts of the country are separated, instead of being combined as




MAP 8. TWELVE PRECIPITATION REGIONS

in Map 1. The latitudinal contrasts in the East are so great, according to Map 7, and to a lesser extent, Maps 3, 4 and 6, that the East is subdivided into 4 regions in Map 8. Data on which Map 8 is based, or their sources, are given in a long article in the *Annals of the Association of American Geographers.* These data refer to the central or core areas of each of the regions.

The twelve regions here delimited are not equally distinct. For some purposes two or more may appropriately be combined; for example, the East might be considered as one great region with two major subdivisions, the North and the South, each of which has two lesser subdivisions. Likewise the Pacific Coast may be classed as a region with two subdivisions rather than as two regions. The boundaries between the regions suggested in the final map are provisional, in some places arbitrary. Future studies, based on more adequate data, will permit a better drawing of the boundaries. But from the evidence at hand, it appears that the United States has distinctly more than the few precipitation regions hitherto recognized.

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## THE SHOWER*

*The landscape, like the awed face of a child,*
*Grew curiously blurred; a hush of death*
*Fell on the fields, and in the darkened wild*
*The zephyr held its breath.*

*No wavering glamour-work of light and shade*
*Dappled the shivering surface of the brook;*
*The frightened ripples in their ambuscade*
*Of willows thrilled and shook.*

*The sullen day grew darker, and anon*
*Dim flashes of pent anger lit the sky;*
*With rumbling wheels of wrath came rolling on*
*The storm's artillery.*

*The cloud above put on its blackest frown,*
*And then, as with a vengeful cry of pain,*
*The lightning snatched it, ripped and flung it down*
*In ravelled shreds of rain:*

*While I, transfigured by some wondrous art,*
*Bowed with the thirsty lilies to the sod,*
*My empty soul brimmed over, and my heart*
*Drenched with the love of God.*

—James Whitcomb Riley

* From *Songs of Summer*, copyright 1908, reprinted by permission of The Bobbs-Merrill Company.

## THINNING FRUIT TREES BY REMOVING THE BLOSSOMS

THE cost of farm labor has nearly trebled since 1914, whereas the price of farm commodities has only doubled. In other words, efficient use of labor is more than ever important on the farm. Further, there is a shortage of labor, so that the farmer must either omit certain operations or perform them in some way that will save labor.

One of the time-consuming tasks that face fruit growers is the thinning and removal of fruit from overburdened trees in early summer so as to lighten the load and favor better size and color of the fruits that are permitted to remain. The task is usually performed by women and children, at relatively low wages. It is a time-consuming chore, the sort of thing that nobody cares especially to do, yet one that is likely to prove very important not only to the fruit but to the tree as well. For, trees which are overloaded with fruit are subject to limb breakage, winter injury, and biennial bearing—that nemesis of the fruit grower which results in a crop one year and none the next. Thus there are important implications in the possibility of "thinning" an apple tree by spraying the tree at blossom time with materials that will remove blossoms and yet leave the proper number for a crop.

But to go back a little way, the crop of fruit for 1944 was determined by the number of blossom buds formed during late spring and early summer of 1943, and this number was determined in turn by the nutritional condition of the trees. Mature trees which either did not blossom or which blossomed lightly in 1943 were likely to have formed an abundance of blossom buds for the crop of 1944; a good supply of available nitrogen is favorable to fruit bud formation under these conditions. This was the situation in many apple orchards during 1943, which was a year of light crops.

And now the season of 1944 approaches with the prospect for a heavy load of fruit, to be aggravated by a goodly supply of available nitrogen, since nitrogen tends to cause blossoms to "set" even at the expense of fruit-bud formation for the next year. Here, then, is a situation that calls for attention. Fortunately, there are suggestions from science which may help.

First of all it has been observed that the removal of blossoms may fulfill a threefold function. It "thins" the crop by removing potential fruits; it removes potential fruits at a very early stage, with much less wastage of plant materials than that caused by thinning half grown fruits; and by preventing an overload of fruit it releases sufficient available nitrogen to provide for fruit-bud formation for the next season's crop.

If all the blossoms are removed from a heavily blossoming tree, an abundance of blossom buds will be formed and the tree will blossom again the following year. A spring frost which destroys all the blossoms does this very thing. And, in this connection, it is interesting to recall that over a century ago an inquisitive horticulturist, Robert Manning of Salem, Massachusetts, laboriously picked all the blossoms from heavily blossoming Baldwin apple trees that bore fruit every other year, while leaving some trees untouched, and so brought about a condition in which some trees bore fruit one year and others the next.

Because of these benefits from blossom thinning, much attention has been attracted to it. Carefully conducted experiments in thinning blossoms of peach trees have shown increased size and color of fruit with no reduction in yield, increased size of leaf, increased terminal growth, generally increased vigor of tree, and more nearly annual bearing. Commercial peach growers, quick to adapt such findings, have already devised "rakes" or "brushes" for carefully raking or brushing excess blossoms from peach trees at the time of full bloom, with a great saving in labor.

Apple trees do not lend themselves so readily to brushing, in part because of the larger size of the trees and in part because apple blossoms commonly occur in clusters of six, in which the central flower opens a day or two (depending upon the weather) earlier than the surrounding or lateral blossoms. Further, it is when apples "set" in clusters that they become most difficult for the orchardist to handle. On the other hand, this arrange-

ment of the blossoms may enable the apple grower to destroy the lateral blossoms, as they open, after the central blossom has set.

This plan was tried, perhaps a dozen years ago, using such sprays as sodium polysulphide, cresylic acid, and tar oil distillates. When it was desired to shift the bearing years of alternate-bearing trees, these sprays proved very effective by removing all the blossoms. But when partial removal of blossoms to a desired degree was attempted, variable results were reported and in some instances severe injury was done to both blossoms and foilage, owing, in large part, to the uncertain and variable composition of the materials employed.

The new "dinitro" compounds developed for pest control (especially the material known as *Elgetol,* the sodium salt of a dinitrocresol) are of more definite composition than the materials mentioned above and can be better relied upon for blossom thinning. When certain "dinitro" sprays were applied experimentally just after the central blossom in the cluster had set, some results were very promising. Other tests have been less satisfactory, because the degree of thinning was unpredictable. Results to date do indicate, however, that these materials can used effectively on the Wealthy and Yellow Transparent varieties. Additional recommendations probably will be made as information is gathered from more extensive trials.

H. B. Tukey

## HIGH VACUUM IN INDUSTRY

Ever since 1643 when Galileo's assistant, Torricelli, discovered the possibility of producing a vacuum above the top of a mercury column by filling with mercury a tube closed at one end and over 30 inches long and then inverting it into a pan of mercury, men have been experimenting with high vacuum. Not until recently, however, have they been able to take it out of the laboratory and put it to work on a large scale in industry, where the reduction in the number of air molecules in a given space makes possible manufacturing processes that are unheard of at atmospheric pressure. The effect is something like taking a factory and moving it into the ionosphere, several miles out from the earth.

Under such conditions the boiling point of a large new class of compounds, such as oils, fats, and waxes, is reduced to a point where they can be distilled without decomposing. Many foods and drugs can be dehydrated without impairing their quality, and various metals produced directly under high vacuum.

Ordinary air pressure at sea level will support a column of mercury 760 millimeters high. In manufacturing operations now made possible by advanced vacuum techniques the air pressure is brought down to the range of .001 millimeters, or 1 micron.

To date micron pressures have been applied on a large industrial scale to the production of war-important magnesium from dolomitic limestone. The War Production Board has called this one of the most important technical achievements to come out of the war.

In addition to this, a High Vacuum Diffusion Process for pumping water vapor under high vacuum has been perfected and applied to drying penicillin. Since it materially reduces the time and cost of dehydration, according to the WPB, most of the larger manufacturers of that drug have adopted it to speed their output.

Previous to the magnesium and penicillin developments, vacuum has been used in various manfacturing processes—in the production of vitamins and the refining of certain chemicals and oils, for example. In the first instance, however, the application has not been on the large scale attained in the magnesium operation, where entire plants with thousands of feet of pipes, valves, retorts, and condensers can be placed under air pressures 100,000 times less than normal. In the second, it has been carried out at pressures in the 5 millimeter range rather than at the .001 millimeter range now attained.

Application of high vacuum to the production of magnesium was advanced when the Defense Plant Corporation awarded a contract to the National Research Corporation in Boston—which had long been doing development work in the high vacuum field—to build a small pilot plant for this purpose. Work proceeded so rapidly that four and a half weeks later this was in operation, producing a sample run of magnesium of high quality.

In making magnesium under high vacuum, bricks of crushed dolomite and ferro-silicon

are placed in a chrome-nickel-steel retort, one end of which projects into a furnace, where it is heated to 1100 degrees Centigrade. The other end, extending out from the furnace, is cooled by a water jacket. The magnesium is vaporized in the heated end and condensed in the water-cooled end, where it collects in crystalline form, the entire operation taking about eight hours.

High vacuum is essential to the process because it speeds reduction of the magnesium-bearing ore and evaporation of the magnesium molecules. In addition, the retort must be free of air because magnesium combines readily with oxygen.

Vacuum equipment designed for this installation was adapted to other large plants. Today several of the country's large magnesium producers are making the metal by this process, using new-type industrial diffusion pumps, together with associated vacuum valves, gauges, and similar parts, capable of exhausting tremendous quantities of air and other gases in record time. These installations have pumping capacities of many thousands of cubic feet per minute in the micron range, and theoretically equipment can be built for any desired pumping capacity.

Many difficult problems, however, had to be overcome before such a high vacuum could be maintained throughout a plant, making the entire system air-tight and keeping it that way. At 1 micron pressure gas expands at an enormous rate, occupying a space 760,000 times greater than it does at normal atmospheric pressure. In addition to exhausting such huge volumes of air to create the vacuum, the gases that are given off during the manufacturing operation must also be continuously removed—a tremendous job in itself, since a piece of metal at atmospheric pressure contains occluded gas at least comparable in volume to the metal itself and often several times this volume.

Keeping the system air-tight presented another important problem that had to be solved before large scale operations of this type became possible. This is an extremely complicated undertaking, since each installation of the equipment to date has created problems of its own which had to be solved individually. In short, a whole new technology of Vacuum Engineering had to be evolved.

Application of high vacuum to the drying of penicillin presented additional problems in vacuum engineering. In the past, freezing methods of dehydration at low pressure have been handicapped by the building up of heavy ice layers in compartments specially designed to collect the vapor as it is evolved. Difficulties have been experienced in attaining the required vacuum and keeping it throughout the operation, since enormous volumes of water vapor as well as air must be continuously removed. To overcome the problem of pumping this vapor under high vacuum, National Research Corporation developed its High Vacuum Diffusion Process, in which vapor and air are both handled independently in the vacuum system with different pumping methods.

Now that high vacuum systems have passed the large-scale threshold, it is predicted that in time new applications of the technique will be made. Use of the High Vacuum Diffusion Process in the drug and food fields, for example, offers great promise, and it is likely that after the war many metals may be produced simply and economically under high vacuum, as in the case of magnesium.

RICHARD S. MORSE

## ROACH CONTROL

THOSE who have read the verses of Archie, the cockroach, who composed laboriously on the typewriter of his boss, Don Marquis, may have a kindly feeling toward these lowly creatures. However, most people regard cockroaches, usually called roaches or waterbugs, as unbidden and unwelcome guests. Archie, who complained bitterly about the persecution of his tribe by the human race, would, if he were writing today, have even more reason to view the future with alarm, for more effective and efficient ways have recently been developed to make his life miserable and insecure.

Mention has already been made in "Science on the March" of the use of boric acid solutions in test tube drinking fountains for control of German roaches. Experimental work is going forward to find out how many, or rather how few, test tubes should be placed in an infested kitchen and where they

should be located, first to reduce the infestation and then to prevent it from building up again. This method of roach control has not yet been tested by pest control operators, although it is more suitable for application by them than by laymen.

Not every one who finds roaches in his kitchen can afford to call a pest control operator. Therefore it is desirable to have on the market a product for roach control that anyone can buy and use safely and successfully. Hitherto a householder could do no better than buy a package of sodium fluoride, a white powder, which by law in some States is colored a greenish blue to distinguish it from flour and baking powder. The buyer then distributes this powder as best he can near places where roaches are believed to hide during the day. The results can be excellent, but the indiscriminate scattering of a poisonous powder in a kitchen where it may contaminate food and utensils should be discouraged.

Recently it was found that sodium fluoride can be molded in the form of crayons. With a crayon in hand anyone can mark on almost any surface a line of sodium fluoride—a deadline for roaches. Thus a deposit of sodium fluoride can easily be put exactly where it is needed—around window and door frames, baseboards, and sinks; in closets and drawers, and under counters or tables. With reasonable care in drawing the lines nothing will be contaminated and when the lines are no longer needed they can be wiped away with a damp cloth.

The armed forces are looking into the use of sodium fluoride crayons and if roaches carried malaria or typhus fever, these crayons would now be used throughout the world. But Archie and his cousins, being relatively harmless, are partially reprieved for the duration. After the war, however, it is to be hoped that John Doe can go to the five-and-ten and buy sodium fluoride crayons in shapes and colors that will distinguish them from chalk sticks.

Until the discovery of DDT (see the February, 1944, "Science on the March"), which may be potent for roach control, sodium fluoride was probably the most effective substance known for speedy and lasting control of German roaches. Being cheaper than DDT, it will not be easily ousted for this purpose . A thin, dry, and powdery deposit of sodium fluoride clings to the feet of roaches that walk in it. Apparently it irritates them, for they remove the deposit by licking their feet. If enough sodium fluoride is thus swallowed, the roaches succumb; if not, they are driven away. Those roaches that pick up the dust on their bodies as well as on their feet are likely to die by contact action of the insecticide. In wet places where a sodium fluoride deposit becomes caked and hard, it is not picked up by the roaches and consequently is ineffective. Therefore sodium fluoride cannot be applied successfully by spraying it in solution or suspension in water. But water is not the only liquid that might be used as a carrier for this compound.

Tests made in the laboratory and in practice during the past three years have shown that sodium fluoride can be applied in suspension in a highly refined kerosene oil in which it is insoluble. With suitable equipment the suspension can be injected rapidly into cracks, crevices, and corners where roaches hide. When the oil has evaporated, the sodium fluoride is left as a dry, powdery deposit in just the right physical condition for maximum effectiveness. In this way premises can be practically roachproofed. Improvement of the dispersion and stability of the suspension and development of suitable equipment for application remain to be done before the method can be widely used by pest control operators.

The foregoing new methods have been proved effective for practical control of German roaches but have not yet been evaluated against the larger common species: the oriental roach and the American roach. It may be found that these species can be controlled better by the use of poisoned baits, particularly by baits containing well-dispersed yellow phosphorus. Roaches are wary of most poisoned baits but the big fellows seem actually to be attracted by phosphorus, which is extraordinarily toxic to them. Much research remains to be done on attractants for roaches. Should a "roachnip" be found, Archie and his relatives might as well give up altogether.

F. L. C.

# BOOK REVIEWS

## WILDLIFE REFUGES

*Wildlife Refuges.* Ira N. Gabrielson. Illustrated. 257 pp. 1943. $4.00. Macmillan.

This book was originally planned to tell the story of the national wildlife refuge system administered by the United States Fish and Wildlife Service. However, as the work progressed it became increasingly evident that the history and philosophy of all types of refuges were so completely intermingled that all should be included and treated as a unit. The plan therefore was revised accordingly, and, while the book is still largely the story of our own national refuges, enough of the history and the status of all other types of refuges in North America has been included to give a rounded-out picture of conditions as they now are. While the greatly enlarged scope of the work obviously has required omission of interesting phases of the conservation story, yet, within space limitations, sufficient material has been included to give a fairly complete account of the work. Much of the information on the National refuges has been taken from the files of the United States Fish and Wildlife Service, but the book has been written against a background of personal observation on the part of the author, in which every major national refuge, except one, has been visited at least once, including most of those in Alaska, and a portion of both Canadian and Mexican parks.

An excellent idea of the general scope of the work may be gained by consideration of its major subject headings. These include such themes as: History of the refuge movement; Purposes, values and limitations of refuges; Types of refuges; Management of refuges; Alaska's great bird cities; Special refuges; The fur-seal islands; Big game refuges; General wildlife refuges; Mysterious Okefenokee; Patuxent Wildlife Research Refuge; Migratory waterfowl refuges; Refuges on land used primarily for other purposes; Refuges administered by other Federal agencies; State refuges; Private refuges, and Canadian and Mexican refuges.

Even during the period of wildest exploitation of our natural resources, there were still a few people who realized the folly of such prodigal waste, but, for a long time, their protests were little heeded by the hurrying hordes bent on conquering and consuming a continent in record time. However, these protests grew in number and in volume through the years and presently developed into the conservation movement that began its sweep soon after the turn of the last century. The story of this halting of greed and exploitation in time to save remnants that can be and are being built back into usable resources is still too recent to be completely unfolded, but it is an achievement that makes an inspiring tale and it should be repeated over and over again. Dr. Gabrielson's book presents one of the important chapters in American conservation history—the story of the growth of the great American National wildlife refuge system, now a major factor in the restoration of our wildlife resources.

J. S. Wade

## EDWARD TYSON

*Edward Tyson, M.D., F.R.S., 1650–1708, and the Rise of Human and Comparative Anatomy in England.* M. F. Ashley Montagu. 56 Illustrations. xxix + 488 pp. Sept., 1943. $5.00. The American Philosophical Society.

As an anatomist and a physical anthropologist I was quite aware that Edward Tyson had contributed to both fields. Prof. Montagu shows in this volume that Tyson was not only a contributor—he was an originator, a founder, a pathfinder. More than that, he influenced not alone biological science but literature and human culture as well. Truly, he was of and for the period in which he lived. The research and the biographical skill of Prof. Montagu brings to life the man, Tyson, and recreates the seventeenth century scientific and social worlds in which he lived.

In 1699 Tyson published *Orang-Outang, sive Homo Sylvestris: or, the Anatomy of a Pygmie Compared with that of a Monkey, an Ape, and a Man.* In this volume Tyson states his aim "to make a *Comparative* Sur-

vey of . . . the formation and structure of all the Parts of this wonderful *Animal* . . . with the same Parts in a *Humane Body.*" This concept of a comparative study was an extension of his 1680 study of *Phocaena, or the Anatomy of a Porpoise* which Prof. Montagu says was the "first monographic study of an animal to be issued in England as an independent publication, outside the pages of a periodical." Tyson's *Orang* was a chimpanzee, and a young one at that. When he compared it to an adult human he made mistakes due to age-change differences. But this in no way detracts from the significance of his contribution of the comparative approach. Tyson's biographer goes so far as to say "no work published before or since has been so essentially a comparative anatomy as the *Orang-Outang, sive Sylvestris.*"

Tyson was not alone a research comparative anatomist, he was a physician also. He described in 1677–78 a case of suppurative cholangitis which "represents, in England at any rate, the first demonstration of the association between certain symptoms in the living and a particular pathological condition in the individual who had died exhibiting them." In 1638 he gave a thorough account of the life-cycle of the tapeworm and the roundworm.

In the field of physical anthropology Tyson provided material for the concept of Primate and human evolution, and for the classification of Mankind. It is no overstatement to say that he prepared the way for Blumenbach, often termed the father of physical anthropology. In addition, we may claim for Tyson an "honored place in the history of the scientific study of folklore." Finally, to him goes credit for pointing out "for the first time in the history of human culture, that an ape-like creature . . . was the closest living animal relation of man."

Prof. Montagu terms this biography a "labor of love"; to which the reviewer adds that most certainly love's labor has not been lost. It is clearly, vigorously written; it is carefully documented; it is copiously illustrated. Tyson and his epoch parade across the stage of Time, spotlighted by scholarly biographical research. In a *Foreword* to the volume Prof. George Sarton states that he would like to know more of Blaes, a Belgian, whose *Zootomia* or *Anatome* (1676, 1681) was the first general treatise on comparative anatomy. Prof. Sarton then says, "When will he be properly montagued?" The coined word is his, not mine—but Tyson has been most ably montagued! A good job, well done.

WILTON MARION KROGMAN

## THE DEAF IN AMERICA

*Deafness and the Deaf in the United States.* Harry Best. xix + 675 pp. Dec., 1943. $6.50. Macmillan.

DR. BEST'S book has been awaited with interest for several years, it being known that the author of a treatise, *The Deaf,* published in 1914, had accumulated a wealth of additional material on a subject little known to the general public. The enthusiasm with which his first book was received served as an impetus for continuing the study of all phases of the deaf, and, from the wealth of material assembled, to bring together within the covers of a single book a reference work that probably has never been surpassed for intensive study and careful compilation. The exhaustive citations and references are essential in a work such as that produced by Dr. Best. Frequently publications have appeared in the past written by individuals whose work, while valuable, has reflected the personal views and prejudices of the author. It is in order to dispel such tendency and to deal equitably with a subject, concerning which there is a high degree of controversy, that the author has laid special stress on denoting the sources from which information has been gleaned. This detail makes the text doubly valuable in that it opens up a wide field for further study and investigation on the part of those particularly interested in some special field of so broad a subject.

Invariably the mind of the uninitiated turns to the charity angle when considering various phases of the handicapped groups. Because of his wide experience in the education of the deaf—the author having spent ten years as instructor at schools for the deaf in Nebraska, Washington, Alabama, and New York—he was in a position to discard the charity angle and to build upon the foundation laid down by the deaf themselves who declare that their greatest handicap is not deafness but rather the difficulty of con-

vincing a hearing world of the capabilities of the deaf. At no time have the deaf more clearly demonstrated the truth of this contention than at the present time, when shoulder to shoulder with their hearing brothers and sisters they are found satisfactorily employed in practically every field of endeavor save where hearing is an absolute essential.

Some of the leading industrialists have long espoused the cause of the deaf and have proven their premise by employing deaf men and women in various types of work where the greatest skill has been required to perform the intricate assignments entrusted to them.

Some of the chapter headings illustrate the breadth and scope of Dr. Best's work. As most of the references made to the deaf in earlier times were centered around such educational effort as was given to certain individuals, the chapters entitled "Education of Deaf Prior to Introduction into the United States" and "History of Education of the Deaf in the United States" furnish a valuable background from the historical standpoint.

The legal status of the deaf throughout the years has received a justifiable measure of attention. A chapter entitled "Legal Treatment of the Deaf" refers to legislative enactments in the various states and by the United States Government. The medical man will find much of value in such chapters as "Causes of Deafness" and "Physical and Mental Condition of the Deaf." Obviously the medical field could not be dealt with technically but the exhaustive references prove most valuable. As a matter of fact, all phases pertaining to the well-rounded life and activity of any group of individuals is here treated. Topics on religious life, methods of communication, the deaf in industry, adaptability in a world of hearing, all receive due consideration.

It is a significant fact that the author has drawn most freely upon articles printed in magazines, state and national documents, and references to the deaf found in the general run of library shelf material. He has studiously avoided the exclusive use of educational literature which has so frequently characterized work on the deaf in America.

Perhaps it is in the field of education of the deaf child that the greatest storm of controversy has raged and here the author has dealt impartially with the various contending factors. The various types of schools and the cost of such education have received abundant consideration.

The work provides an indispensable source of information for students of psychology and sociology. Every teacher of the deaf will find within its pages information that will aid in classroom problems. Parents and friends of the deaf will gain a new concept as to the capabilities of the deaf and the general public will be informed as to society's responsibility to this group.

Most significant in a study of the deaf is the fact that misleading nomenclature, such as the use of the term "deaf and dumb," or "deaf mute," has created preconceived notions of physical and mental inferiority that are contrary to fact. On this subject the chapter entitled "Popular Conceptions Regarding the Deaf" will prove illuminating.

To recount the personal sacrifices made by the author, whose very life blood flows through the pages of the book, would make interesting reading. It is merely mentioned in passing as a fitting conclusion to the review of a book which has been the focal point of attention on the part of an indefatigable student over a period of thirty-five years.

IGNATIUS BJORLEE

## ORIGINS OF AMERICAN SOCIOLOGY

*Origins of American Sociology: The Social Science Movement in the United States.* L. L. Bernard and Jessie Bernard. xiv + 866 pp. 1943. $6.50. Thomas Y. Crowell Co.

THIS book is an account of the theory and personnel of social reconstruction in America during the 19th century. From the eighteen-forties to the eighteen-nineties social science was directly tied to reform organizations and activities. This union of science and the urge to human betterment eventually split into two parts. One component was further specialized into the several social sciences which, in due course, were institutionalized as academic disciplines. The other aspect of the movement, the interest in larger reforms, was usefully trivialized into social work, associated charities, and other welfare activities.

Intellectually, the movement began as utopian speculation, became more concrete investigation and limited agitation for specific reforms, and ended in the present-day social sciences with their historical and statistical designs of scientific studies. The early "associationist" movement, an American derivative of Fourierism, declined in the forties and the general movement took a more systematic bearing from the writings of Comte and Spencer. For many years these writings were assimilated and sometimes transformed. Their selective reception into American reform thought is well presented by the Bernards. In the seventies, political economists gave the general movement an economic welfare slant.

These economists, with other individuals interested in welfare activities and thought, founded the American Social Science Association in 1865. This association directly or indirectly gave rise to conferences on child welfare, prison and social work, as well as the several professional associations of the contemporary social sciences. In one of these special sciences, sociology, the welfare urge of the 19th century movement was continued.

The "origins" treated in this book, however, are relevant to contemporary sociology in only a limited manner. Courses in juvenile delinquency, crime, and social problems have persisted and remain quite central, but in the twentieth century the intellectual ferment in sociology has been in the fields of social psychology and social theory. These have been fertilized, and in some cases been given new orientation, by European, especially German, social thought. Nevertheless, the materials so skillfully treated here are undoubtedly among the major antecedents of contemporary sociology.

The account of how the general movement crept into respectable college and university courses is probably the most useful section of the book. A great deal of primary research was involved in obtaining precise information on the introduction of social science courses in large universities and smaller colleges. Historians of ideas and of educational institutions will be grateful to the Bernards for gathering and presenting this information.

The key interest of the social science movement of the 19th century lies in its attempt to apply science to social problems without explicit political support or tactics. It tried to blend social theory with largely nonpolitical practice. After 1900 this attempt had run its course; the larger welfare urge quite understandably became more political. Remnants of the welfare movement survived, in modified forms, in governmental bureaus and policies, and in welfare organizations. The larger urge has been specialized into respectably technical academic thinking, or has grown with the times into explicit political ideology. In the latter case, it has come to be considered inappropriate for the academic man, the governmental official, or the welfare enthusiast.

C. Wright Mills

## MAN AND HIS HABITATION

*Man and His Habitation.* Radhakamal Mukerjee. xv + 320 pp. 1943. $3.50. Longmans, Green and Company.

Professor Radhakamal Mukerjee of the Department of Economics of the University of Lucknow, India, is one of our foremost socioeconomists, well known for his pioneering studies in Indian economic and population problems.

In this volume, which is a series of lectures delivered under the auspices of the Faculty of Science of the Lucknow University, Professor Mukerjee offers a systematized study of the materials and methods of Human Ecology as the basis of functional and quantitative sociology. This is possibly the first scientific study where the various functions and forms of human habitation with special reference to India are discussed. In some eight brilliant chapters the patterns of human habitation like the hamlet, village, small town, and city are described in relation to the density of population, physical and social nobility, man's spatial needs, and food supply.

It is interesting to find that this study suggested itself to the writer, not in the crowded plains of the Ganges Valley where he lives, but during a brief sojourn in the Middle West and the prairie country of the United States. Consequently the author has fully utilized the American contribution to his

field, particularly the discussion of Professors E. W. Burgess, Clifford R. Shaw, R. D. Mackenzie, and H. W. Odum. The result is Professor Mukerjee's canvas in the United States, in fact the whole world, though his treatment of the planning of patterns of human habitation in India is the unique part.

The scope and interest of this volume cannot be limited to any particular branch of study. As this embraces many fields it should be of considerable value to geographers, sociologists, economic planners, and social engineers.

Professor Mukerjee's study is a welcome contribution to the meager literature on the application of ecology to the study of spatial distribution of population and habitation forms. Mukerjee's scientific analysis of aggregation and concentration, mobility, specialization, distance, spatial adjustment, transportation, food supply, and urbanization is a positive contribution to strengthen the movement toward making human ecology the basis of functional and quantitative sociology.

S. Chandrasekhar

## NEW SCHOOLS FOR A NEW CULTURE

*New Schools for a New Culture.* C. M. MacConnell, E. O. Melby, and C. O. Arndt. xii + 229 pp. Nov., 1943. $2.50. Harper & Brothers.

The Superintendent of the Evanston, Ill., Township High School (Francis Bacon) is one of those forward-looking school men who believes that experimentation by competent teachers working in a public high school may be advantageous to the pupils of that school and possibly may produce results useful to other schools. Thus his high school became the locus of an important experiment. This importance was enhanced because the school's executive officer, Mr. MacConnell, and two members of the School of Education of Northwestern University (E. O. Melby and C. O. Arndt) wished to test their talk about education by actual trial of their ideas with sure-enough school situations. The fact that during the five-year experiment Mr. Melby became Chancellor of the University of Montana did not entirely divorce him from the project before completion of this volume. The reviewer interprets the volume as a report of progress. It is to be hoped there will follow a further volume a few years later when the progress of pupils in after-school years may be fully reported.

As the title indicates, the volume is based upon the claims that schools are not now "democratic," and should become so; that the content of the course of study and ways of doing things in schools should reflect the kinds of life we should like to have people live; that each individual possesses "unique human worth" which must not be ignored; and that individuals and their groups should be guided "toward realistic appraisal of the world in which we find ourselves and toward appropriate activity in respect to it." Those claims, the authors state, hold for elementary, high school, and adult education. Indeed, much of the general discussion of the book is designed to apply to the whole program of education as well as to the particular high school used in the experiments. If science ever faces its most important problem it must apply its methods and ideals in the area of human relationships, as well as in the specific problems of biological, physical, and astronomical sciences. "For science is experimental action."

Obviously, the attitude-training of a teaching staff came first, and unsympathetic or ununderstanding staff members were supplanted by others. The most important part of retraining of teachers was accomplished by use of classes of pupils, thus teachers learned while they taught. That should always be true. Then two major subject-matter reorganizations were made. One of these produced the "core program," the other a general language course. Part of a pupil's day was devoted to selected projects, part to regular subject recitations. For example, one pupil used one or more periods in reading books and magazines or in preparation of a report on the history of automobiles. During another period this pupil was in an algebra class taught by a teacher of mathematics. During another period he was a member of a letter writing class in which all pupils and the teacher wrote real letters which a class member took to the post office. That he was called the "core postman" does not seem important. This sample pupil then reported for general language where vocabu-

lary building was studied. Next came gymnasium in which the pupil chose the type of game or exercise in which he would engage. Then the school day was over, with further free opportunity in library, on playing field, or a walk homeward. No two pupils need have identical daily programs, and pupils of different school years usually were found working together in the same class. All worked in groups of twenty-five to thirty in the ninety-minute period given to the "core program," following which individuals could devote their time to such special interest courses as commercial studies, shop work, home making, or college preparatory subjects.

The objectives, according to the author, were difficult to define because of the experimental nature of the New School. The following major objectives were recognized: reflective and critical thinking; basic skills in learning and in expression; social adjustment; subject mastery. The enlargement of these objectives, too extensive to include in a review, gives explicit meaning to them. The core program for one group or for one year changed from group to group and from year to year. No syllabus was prepared, but descriptions of the experiences of individual pupils furnished guides for subsequent school procedures.

The "evaluation of student effort" included an estimate "by the group of a student's single effort in core studies"; personal estimates of "an individual student's general effort and social effectiveness"; and reports prepared and sent home by the teaching staff. Reading the chapter on evaluation fails to give this reviewer a clear idea of desirable exactitude expected and secured in pupil achievement.

The larger part of the book is devoted to the authors' discussions of educational theory, of the need for types of education to prepare people for a "new culture," of changing attitudes and motivations so that "education becomes functional for the individual and for society." That is, "Action, controlled, co-ordinated and purposeful must be the final aim of all educational effort." These discussions are unusually cogent and will be studied with sympathetic interest by that rapidly increasing part of society which really and anxiously believes that education needs to undergo fundamental changes if it is to become our hoped-for major agency for producing an intelligently competent, an unselfishly cooperative, and an enduringly purposeful society.

OTIS W. CALDWELL

## THE CHEMIST

*So You Want to Be a Chemist?* Herbert Coith. x + 128 pp. 1943. $1.50. McGraw-Hill.

THIS little book is enthusiastically called to the attention of those whose sons or daughters have expressed interest in chemistry or are already in technical schools of chemistry or chemical engineering. Dr. Coith gives the reader the facts of life of the industrial chemist. In a highly entertaining fashion he describes the kinds of work that chemists do in industry, the type of man that chemical industry wants, and other aspects of the subject that would help a young person to decide whether he should or could become an industrial chemist.

The reviewer was so fascinated by this book that he continued to read it on a rocking street car and on a vibrating, dimly lighted bus. If a similar book had been available to him when he was a senior in chemical engineering, in all probability he would now be working with Dr. Coith in the Proctor and Gamble Company, for, not knowing the facts of chemical life at that time, he appalled a personnel officer of P & G by an irrelevant job letter and was not hired.

Dr. Coith's book has a flavor rarely attained even by professional writers. Without resorting to the tricks of popular science writers, he is simultaneously humorous and serious, modest and wise. He knows his stuff, as the boys say. The reviewer recommends that this book be read not only by students of chemistry and chemical engineering but by everyone who has wondered about chemists and who appreciates good writing.

F. L. C.

# COMMENTS AND CRITICISMS

### Henry George

Mr. Davies raises some interesting points in your March issue but are his assumptions sound or his premises justified? He assumes that private earnings "may be broadly classified as payments for personal services and payments for saving" but does this show the true relationships? Do we pay "for saving" and can interest be so regarded? Is there any clear demarcation between payment for services and payment of interest? Capital, in a sense, earns its own interest by the added efficiency which tools give to labor.

What we earn may take the form of wages to be spent for today's needs, or it may take the form of capital to yield that deferred, prolonged, and greater return which we call interest. The farmer may eat up his consumption wages in eggs or in broilers, or he may hatch the eggs, accumulating capital in the form of a laying flock, but he cannot have it both ways for eggs eaten will never hatch. And of course interest is justified for otherwise he receives no compensation for foregoing today's desires.

Guesses of the share of production which goes in interest lead only to confusion, for the greater part of interest can never be unscrambled from the direct wages of labor. How much of the income of each craftsman is interest on capital in tools—the plows of the farmer, the sewing-machine of the tailor, or the kit of the carpenter? These things are all capital and, used, earn interest, but can figures for all the nation be broken down? The farmer who builds a stone-boat must forego the food which he might have been raising, but the added efficiency which the equipment gives in clearing his fields is interest on the capital produced.

Mr. Davies says that Henry George "failed to note that the original earnings of land provided funds for the early stages of capital investment," but land earns nothing: it only makes it possible for labor to earn. Rent, collected by the landlord, may or may not be spent, or invested as we say, in true capital, but, collected by the state, it is similarly invested in capital, as in roads, schools, or waterworks, and the status of rent is unchanged regardless of who gets it. What part does rent play in enabling the savage to make the bow or the canoe? Capital is always the product of labor, and operations of the market only affect its ownership. Uninvested money is capital only potentially, as is unexpended labor, and stocks, bonds, and bank balances are only vouchers representing real things which may or may not be capital.

The simple fact is that all that man has and enjoys is obtained by labor, whether of brain or brawn. Rent we must always have, as long as land differs in desirability, for it arises from this differential. It may go into private pockets, forcing the citizens to dig into their earnings to support government, but, if returned to all in the operations of government, such exactions will no longer be necessary and man's labor can be freed from this heavy toll. This, to the writer's mind, is the heart of George's philosophy.—Gilbert M. Tucker.

### Corset Isn't

Allow me to draw your attention to the article that appears in the February issue of your magazine under the title "Thomas Paine: Scientist-Religionist" by Ralph C. Roper. I quote a few lines from the 1st column, page 101: "Herschel was a musician; Paine, a staymaker—of ship stays."

In the *Readers Digest* magazine, issue of March, page 78, there appears an article under the title "Tom Paine, Crusader for Common Sense" which article is condensed from *The New Leader* by Max Eastman. From page 78 I quote as follows: "Obscure British corset maker who landed at Philadelphia in Nov. 1774." Again on page 79 we read: "After leaving school at 13 he learned his father's trade of staymaker, fitting whalebone corsets."

So I am just wondering whether Tom Paine made corsets for ships or for the ladies; perhaps you can enlighten me.—H. Hall.

May I offer the following to support my claim that Paine was not a corset maker, and that he was a maker of ship stays:

Thetford, where the Paines lived, was alive with fishermen and fishing boats, and one of the main occupations was the making of ship stays.

Peter Eckler, in an early biography of Paine specifically states: "It is probable that Paine acquired in the manufacture of ship stays, the skill which enabled him to forge and manufacture with his own hands the models for his iron bridge."

The claim that Paine was a corset maker has been of more modern origin. X. Y. Z———, it is quite evident, thought it would help to sell his book to couple it with some of the worst of falsehoods. Hence, he had Paine, at the age of 13, sticking his head up against the "belly" of a 200 pound woman, in an attempt to adjust her corset, and his Quaker father swearing at him because he was not working fast enough! No, a more useful ship staymaker of the Quaker temperament is not as exciting to readers who demand not only jazz language but also jazz sentiments. It may be that Mr. Eastman, in the *Readers Digest* article, followed the lead of Z—— in classifying Paine as a corset maker. Anyhow, it is, I believe, far from the truth.—R. C. Roper.

### A Scutching

Dr. Alexander F. Skutch has gently remonstrated our failure to give the scientific names of the birds that played the principal roles in his "Parable for Peacemakers" (*The Scientific Monthly*, April, 1944). Their names are as follows: The striped flycatcher is *Legatus leucophaius;* the gray-capped flycatcher, *Myiozetetes granadensis;* and the chipsacheery flycatcher, *Myiozetetes similis*. The three are members of the family Tyrannidæ.—Eds.

### Transposition

Congratulations on the "new" *Scientific Monthly* with only one querulous word. Why continue the annoying habit in the book reviews of indicating the book concerned with a footnote? Everyone has to glance down and back. Since *the book* is the subject of the review for God's sake (and mine) put the significant data of title, etc., right at the head of the article.—H. E. Rawlinson.

Amen.—Eds.

### Ups and Downs

In the January 1944 number there is a very interesting article on the Amazon by Albert F. Kunze in which on page 18 he says "of the newly founded city of Santiago de Guayaquil, situated *high among the peaks of the Andes*" [italics mine]. The city of Guayaquil has always been practically at sea level, only 30 miles up the Guayas River from the Gulf of Guayaquil, into which it empties.—James Birch Rorer.

Mr. Rorer, who lives in Ecuador, pointed out not only the true location of Guayaquil, but also two other errors to which we previously confessed in this column. We wish that we could send copy to him in advance of publication.—Eds.

### Shall We Speak Out?

From multiplex experiential fronts
We must at times to inner room withdraw
And ponder meaning in some hope to see
Synthetic bits of universal law.

To oft emerging from that cell to light
We bring no message, yet discern the flaw.
Upon that page our shadows fell so dark
That what we drew but outlined what we saw.

At times the ego merges with the All
And lets the light of truth prevail.
Then do we feel impelled to sing
Or picture nature's wondrous tale.

In this so strange for those immersed
In scientific lore, whose life is spent
In analytic test and measurement,
Of changing form and planned experiment?

Truth comes in many forms, and beauty too,
May peer from graphs and metric formulae.
The reach of mind beyond its data soars
To make its greatest gains, and we are free
To test and seek some more.

Mankind is still emotion geared
With hymns of hate and love.
Behind the scenes stalk want and fear
And over all the crowding sphere
The master problem proves.

So therefore build and carve and draw,
Deduce, conclude and write as law
What seems so clear to you.
Fear not to seem beyond the pale
For yet no sacred mode prevails
To voice a message true.

—John G. Sinclair.

THE SCIENTIFIC MONTHLY

JUNE, 1944

# PENICILLIN*

By ALBERT L. ELDER

For centuries man has depended, directly or indirectly, upon fermentation reactions for the destruction of waste materials and the production of valuable compounds. As an example, the beverage industry, which dates back to Biblical times, has been developed to a very high technological state, and further improvements in yield or decrease in the time cycle may be difficult to attain. Present day competition between some synthetic and fermentation processes is keen, and there is reason to expect that it will continue to be so. Many commercial fermentation processes result in high conversions of carbohydrate into the desired end product. Among the high yield fermentations are those of alcohol, acetone, acetic acid, butanol, butyric acid, citric acid, glycerol, gluconic acid, kojic acid, lactic acid, and l-sorbose, for in these the conversion of carbon into the desired material varies from 20 to 97 percent. It is only within recent years that attempts have been made to harness low-yield fermentation reactions on a commercial scale and to isolate desired substances therefrom.

Based on the cost of equipment for its production, penicillin is by far the most important of the low-yield products. At the present time, the formulas for fermentation media used in producing penicillin vary greatly in different plants, but calculated on carbon content of media converted into carbon in penicillin, the yield is only about 0.005–0.1 percent. Yields of this order of magnitude are most fascinating to the scientist, for he dreams of the day when he might obtain one percent conversion. It is almost incredible that we would spend approximately twenty million dollars on equipment in which to carry out such an inefficient reaction. But we who have been connected with the commercial production of penicillin are proud of the accomplishments thus far, yet humble when we realize how little is known about the mold, *Penicillium notatum,* and the mechanism by which it produces penicillin.

Several crystalline antibiotic substances have been obtained from bacteria and molds. These substances have the capacity of inhibiting growth and destroying various bacteria. In general, they are bacteriostatic, rather than bactericidal, and are selective in action. In vivo their bacteriostatic ability may differ greatly from that in vitro. At the present time, penicillin is the most important of these antibiotic substances, for it is reasonably nontoxic and therefore can be used in vivo. It is particularly effective against most of the gram-positive cocci and bacilli, and the gram-negative diplococci. Streptococci, staphylococci, pneumococci, the clostridium group, gonococci, meningococci, and spirochete and actinomycete infections respond to its use. Penicillin has not been shown to be effective against the gram-negative bacteria, tubercle bacillus, malarial parasite, Friedländer's bacillus, and many others. Although called the "miracle drug," its uses *are limited* and the method of handling the drug clinically leaves much to be desired.

At present penicillin is delivered to the physician as penicillin sodium, the sodium salt of an organic acid. Several other metal-

* An address delivered on March 29, 1944, at the Tenth Annual Chemurgic Conference, St. Louis, Mo. Acknowledgement is made to the National Farm Chemurgic Council for permission to publish it.

lic salts have been prepared, and it is quite likely that some other one may soon supersede the sodium salt. Penicillin is affected unfavorably by high temperatures, moisture, and acidic and basic conditions. At present the ampoules of the drug are kept at temperatures below 10° C. (50° F.) and have an expiration date of three months from date of testing and filling, except for three companies with a six months' dating and one with four months. Because great losses are encountered in purifying the drug, it is used in the relatively impure state, but before long a product containing at least 50 percent penicillin should be produced on a commercial scale. The pure salt is crystal clear. At present penicillin is administered intramuscularly, intravenously, by lumbar puncture, directly into joint and cavity spaces, and locally—oral administration is not effective. The amount required per case ranges from about 100,000 units to a few million. One billion units of pure penicillin weighs approximately one pound. It is hoped that someone will discover a derivative of penicillin which can be administered orally and further that the stability of the drug will be improved greatly. Also, it is possible that some derivative of penicillin might have a much wider bacteriostatic action.

Numerous articles have been written pertaining to the accidental discovery of the bacteriostatic action of *Penicillium notatum*. It is with considerable chagrin that we must admit that a drug of such potential usefulness remained dormant for so many years. Were it not for the war, it is most likely that it would still be little more than a laboratory curiosity. The bacteriostatic effect of penicillin was first observed by Dr. Alexander Fleming, Professor of Bacteriology at St. Mary's Hospital, London, in 1929. A spore of the mold contaminated a Petri dish containing a culture of *Staphylococcus aureus*. The growth of this organism was inhibited by the mold, later identified as *Penicillium notatum*. Fleming studied the material and suggested that it might have clinical value, *if* it could be produced on a larger scale.

Professor Harold Raistrick of the London School of Hygiene and Tropical Medicine produced larger quantities of penicillin and studied its properties in some detail. He urged that it be subjected to clinical tests, but the small yields made this impractical at the time of his publication in 1932. For seven years little was done with penicillin. In 1939 the Oxford group under the leadership of Dr. H. W. Florey revived penicillin as a possible war-time drug. In 1939 a Rockefeller grant of $5,000 was made to support the work and again in 1941 another $5,000 grant was made. In July, 1941, Dr. Florey and his associate, Dr. N. C. Heatley, visited the United States and made their findings available to some American workers. The early work in the United States was under the guidance of the Office of Scientific Research and Development.

During the past two and one-half years penicillin has gone through all the growing pains usual to any new industry. Production was still in the laboratory stage when information about it was brought to the United States in 1941. The yields were hopelessly low, and the recovery process was far from satisfactory. War-time conditions in England made its rapid development very difficult in that country. Among those contacted in the United States was Dr. Robert D. Coghill, Fermentation Division, Northern Regional Research Laboratory. His group, with their broad experience in fermentation, tackled the problems of increasing the yield and recovery. Dr. A. J. Moyer, a co-worker of Dr. Coghill, discovered that the addition of corn steeping liquor to the medium upon which the mold grew increased the yield tenfold. New strains were developed, and in a short time the yield had increased from two up to forty Oxford units per cubic centimeter.

Within a few months the firms of Merck, Squibb, Pfizer, Abbott, and Winthrop were producing enough penicillin for some clinical tests. As clinical results were obtained, the potential usefulness of penicillin became more exciting. Only experimental quantities of penicillin were produced in 1942, and only 400 million units during January to June of 1943.

The armed forces recognized that thousands of lives might be saved if penicillin could be produced on a commercial scale. The responsibility for this production rested

with the Drugs and Cosmetics Section (now a Branch) of the Chemicals Division of the War Production Board. Mr. Fred J. Stock, chief of this Section, was given "guestimates" for requirements and promises for processes, and on this footing the program was launched. Mr. Stock recognized the potential usefulness of the drug and therefore urged industry to tackle this problem.

During the next few months processes were improved. Starting from the drawing board, plants had to be built. Most of the construction program was done during the months of October, 1943 to March, 1944. The production in June was 0.4 billion units; July, 0.7; August, 0.8; September, 1.7; October, 2.8; November, 4.8; and December, 9.1. The production in March should be at least twice the total production in 1943 and rapid increases should follow each month for several months to come.

The production of penicillin may be divided into the following steps: (1) isolation of a pure culture of *Penicillium notatum* and recovery of spores of the mold, (2) preparation of inoculum from pure spores, (3) preparation of a sterile medium, (4) inoculation of suitable medium with spores under sterile conditions, (5) growing cycle under careful control of air and temperature, (6) separation of mycelium from liquid medium containing the penicillin, (7) concentration and recovery of penicillin, (8) packaging under sterile conditions, and (9) assay of products.

Many methods have been suggested for growing penicillin, and the War Production Board evaluated carefully all proposed processes. Great publicity was given to the cookstove method, the utilization of the home photographic darkroom, and several others. The man-hours required to produce appreciable amounts of penicillin and the lack of uniformity of product made such proposals untenable. Four methods have been tested in great detail. These are known as the trickle process, the bran process, the surface process, and the submerged process.

In the trickle process the inoculated broth is allowed to flow over stones or wood chips under aerobic, sterile conditions. The liquid flows by the mold, which clings to the supports. It is an adaptation of the "quick" vinegar process. Based on its present yields, the cost of equipment is such that this process is not promising.

Sterile bran can be inoculated with spores and penicillin extracted from the bran after a suitable incubation period, but size of equipment and difficulties with temperature control and sterilization have been troublesome. The cost of operation of such a plant cannot be evaluated at the present time.

The oldest method for producing penicillin was that of growing the mold on the surface of a quiescent medium under sterile conditions. Flasks, milk bottles, and trays are used. Some of the "bottle" plants must handle many thousands of bottles per day. Yields are good, growing cycles are long, and labor costs are high. Unless some improvements are made in the process, bottle plants cannot operate as economically as the deep fermentation plants.

*Penicillium notatum* has the interesting characteristic of growing also under submerged conditions. Different strains are used for the submerged process. The mold, as it grows in the broth, is aerated for several days in large fermentors. At the end of the fermentation cycle the mycelium is filtered and discarded, and the penicillin is recovered from the broth. Tanks holding several thousand gallons are now in successful operation, and should the expected improvements follow, this procedure assures us of a high output and cheap method for the production of penicillin.

The recovery of penicillin from the broth follows somewhat the same pattern irrespective of culture media or growing conditions. At the end of the growth cycle penicillin is present as a soluble salt in the broth in a concentration in the range of that of bromine in sea water; but recovery of bromine from sea water is simple when compared with the recovery of penicillin. Many of the chemists' tools and tricks of the trade have been applied to the problem. Several methods have been developed and although some are usable, none is entirely satisfactory. The procedure first published by the Oxford group depended upon acidifying the broth to a pH of 2.0 to 3.0, extracting the penicillin with a small volume of an organic solvent

such as chloroform or amyl acetate, and then extracting the penicillin from the organic solvent with an alkaline solution. By appropriate cycling, purification and concentration can be accomplished. Approximately 50 percent of the penicillin is lost during the recovery process. If this serious loss can be reduced, production may be increased without further plant expansion.

Penicillin is unstable in aqueous solutions and therefore must be packaged as the dry salt. The technique used to dry blood plasma has been applied to the drying of penicillin. Although this method is workable, costly equipment was necessary, because time was lacking to develop a cheaper method of drying.

Since the final substance must be injected into the body, elaborate procedures are used to insure a nontoxic, sterile, pyrogen-free product of uniform potency. This phase of the program is under control of the Food and Drug Administration. The labor required for such controls makes it impractical for hundreds of producers to enter the field.

As coordinator of the penicillin program from October, 1943, to March, 1944, it was my privilege to participate in this thrilling development. It has been a three-way race all through this program among rushing to completion the eighteen plants in the United States and two in Canada, developing a suitable process so the plants could operate when they were physically completed, and trying to synthesize penicillin. Some companies were pushing one group of men to get a plant built, another group to develop a suitable fermentation process for the plant, and still another group to learn how to synthesize penicillin. If the last had been successful, the fermentation plant might have become obsolete before completion.

The army expediters, under the able supervision of Major Frank Sleeter, assisted the War Production Board staff in breaking bottlenecks in equipment and construction materials. The speed with which some of the plants were built is testimony to American initiative.

The Office of Production Research and Development of the War Production Board was called in to break technical bottlenecks, and research projects were started almost overnight at Pennsylvania State College, University of Wisconsin, University of Minnesota, Massachusetts Institute of Technology, and Stanford University. Dr. T. K. Sherwood at M. I. T. advised on methods of drying and packaging the final product. Fermentation problems were assigned to Dr. W. H. Peterson and his group at the University of Wisconsin. Dean Whitmore of Pennsylvania State College placed a group of chemists and chemical engineers on recovery processes. Plant pathologists, led by Dr. E. C. Stakman at the University of Minnesota, have been organized to search for new and better strains of molds which produce penicillin. The group at Stanford, under Dr. G. W. Beadle, have been assigned the problem of producing changes in the mold which may increase the yield of penicillin. The army assigned Capt. A. B. Hatch to my office to follow the biological developments. Samples of soil have been collected from all parts of the world, and a systematic program has been outlined in an attempt to improve the yield.

Additional research on penicillin, some of which was sponsored by industrial firms, has been carried on for some time at Northwestern University, Columbia University, The Ohio State University, and several others.

A very low order of probability exists that we are now using the best possible strain of *Penicillium notatum*. To pick the winner would be like choosing the winning horse in a race with a thousand horses at the gates. Measuring the productivity of a mold is slow, tedious work, and attempts to produce changes in the mold may be unfruitful. However, work of this kind, if successful, could increase production so greatly, that anyone connected with the program who failed to consider and investigate these possibilities would be failing to meet his responsibilities. Since October 1, 1943, Dr. L. A. Monroe has been devoting full time to coordinating the O.P.R.D. projects, and his assistance has been of great value in developing the technical aspects of the program.

In October, 1943, the govermental responsibilities in connection with penicillin were established on clear-cut lines. The re-

sponsibility for the production of penicillin by fermentation methods was taken over by the War Production Board, and the synthesis of penicillin was left under the control of Dr. A. N. Richards and his Committee on Medical Research of the Office of Scientific Research and Development. The recovery of pure crystalline penicillin from mold has been reported in the newspapers. Progress on synthesis is clothed in deep veils of secrecy, but we shall know eventually whether the program was a dismal failure or a brilliant success. Should synthesis not be announced in the near future, new groups of chemists will undoubtedly tackle the problem.

At a dollar per 100,000 units, penicillin would cost about $10,000 per pound. Therefore, attempts to synthesize penicillin will continue for some time to come. The question is frequently asked, "What will happen to the twenty million dollar fermentation investment if penicillin can be synthesized economically?" The plants producing penicillin by submerged methods can be converted quickly to produce other chemicals by fermentation methods. The bran plants are also applicable to other uses. The bottle plants may be saved by the development of other antibiotic substances. If not, some of the equipment will be of little use. In fact, the bottle plants, although the surest bet a year ago, may be forced out of production within the next year, even though penicillin is not synthesized.

The distribution of penicillin for civilian use up to the present time has been under the control of Dr. Chester S. Keefer, Evans Memorial Hospital, Boston, Massachusetts. His job has been most trying, and one exceptionally well done. The clinical research under his supervision has been carried forward very rapidly. As soon as the needs of the armed forces can be met, penicillin should be available for civilian use. Difficulty is to be anticipated in the equitable distribution of so valuable a drug when the demand exceeds the supply. The potential demand for penicillin cannot be evaluated with any degree of accuracy until more is available for clinical tests on humans and animals. The needs of the world for the drug are staggering. Its value in treatment of animal diseases has not been tested. The final price of penicillin will determine its use for many purposes.

Approximately fifty different chemicals are required for the preparation of inoculum and culture media, and for the recovery and testing of penicillin. Mice and rabbits are needed for animal testing. The raw material requirements for the preparation of a suitable substrate and for the recovery processes run into millions of pounds per year. Fortunately, there is at least one substitute material for nearly every step in the process. Thus although one sugar may be excellent for the fermentation media, by proper modification other carbohydrates may be used. Even though corn steeping liquor has been shown to be a valuable adjunct to the media, it is quite likely that still better substances will become available. Several organic solvents can be used in the recovery process. The salvation for large-scale production of penicillin has been the recognition that several methods for its recovery had to be developed. If a single process had been selected and only one recovery system used, the construction of the plants could not have been attained in such a short time; and even though physically completed, the raw materials would not have been available for the operation of the plants. To have standardized the process five months ago would have stifled progress. Attaining maximum production today depends upon the efficient harnessing of the "know-how" recently developed by the technical men.

The one American deserving of the most credit for his contribution in the penicillin program is Dr. Robert D. Coghill, Chief of the Fermentation Division of the Northern Regional Research Laboratory. His group made commercial production a reality, and his fundamental research, which is still being continued, adds each day to the knowledge required to hasten civilian distribution of penicillin. Also, hundreds of technical men throughout the industry have worked as never before to push this program to the limit. The close cooperation between government and industry has resulted in one of the most rapidly developed programs since the war began.

# SENESCENCE AND INDUSTRIAL EFFICIENCY*

## I. THE GENERAL PROBLEM

By EDWARD J. STIEGLITZ

The primary object of industrial health activities is to increase work efficiency of personnel and thereby to reduce costs and speed production. Both historically and in present day application industrial health is divisible into three distinct fields of effort. The earliest phase was limited to surgical and medical repair and rehabilitation of employees injured on duty. Later came recognition that physical injuries could be prevented by control and improvement of the work environment. Thus industrial hygiene was born. Its growth has been rapid and dramatic. The Industrial Hygiene Foundation of America was created to foster further improvement of the work environment; its accomplishments are too well known to require comment. The third, and as yet only scantily developed phase of industrial health, consists of efforts directed toward improvement of the health of individual workers so that they may be more effective in any environment.

Man's ability to work is affected by many factors. These fall into two large categories. First are those factors arising from adverse environmental conditions. Extreme heat or cold, improper illumination, annoying and irritating dusts or fumes definitely impair work efficiency, even without taking into consideration their cumulative ill effect upon health. These are the exogenous factors. Though of vital importance to industrial health maintenance, they are outside the field of this discussion. The second category of factors affecting work efficiency are endogenous; they arise within the worker himself. To maintain maximum efficiency, the human machine must be mentally and physically healthy. Ill health occurs in many degrees; impairment of work capacity is equally variable. Acute illness may make for temporary total incapacity. Chronic illness may either cause brief periods of recurrent total incapacity or continuing partial impairment. Physical defects may limit capacity to work to certain tasks. Fatigue and other intoxications reduce industrial efficiency. Age likewise affects work capacity.

Senescence is that part of aging which occurs after the peak of full maturity. Aging is a series of changes which begin with conception and end only with death. Though continuous, the rate of change is not uniform. The first overt consequences of senescence usually become manifest somewhere near forty years of age, although occult changes have been progressing for years before this time. For convenience in discussion we may divide the later half of life into three periods: later maturity or early senescence (approximately 40 to 60 years), late senescence (60 to 75), and senility (after 75). The critical period is that of later maturity or senescence.

### Need for Knowledge

Interest in the science of gerontology, which is the study of aging, is relatively recent. Aging was long taken for granted. The false notions that senescence is all decline, that it is merely the precursor of senility and death, and that nothing can be done about it are still held far too commonly. True, the aged, like taxes, have always been with us, but never in such alarming numbers as today. It is the recent tremendous relative and absolute increase in the number of elderly persons which makes urgent the need to learn much, much more about senescence than we now know and to apply with energy and intelligence that which we already have learned. The radical changes in population structure are of great significance to every man, woman, and child in this great country, but most particularly they are of moment to Industry.

In 1900, the average life expectancy at birth in the United States was only 47 years; in 1930 it had risen to 60 years and in 1940 to over 63 years. A rise of 16 years in ex-

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pected longevity in only 40 years of elapsed time gives one occasion to pause and to think. Equally dramatic is the rise in median age of our population from 26.4 to 28.9 years in a single decade from 1930–1940. In 1900 only 17 percent of the total population had reached an age of 45. In 1940, 26.5 percent had passed the convenient meridian of 45. Conservative estimates by the United States Bureau of the Census, assuming no net immigration or emigration and ignoring the effects of the war, predict that in 1980 more than 40 percent of our people will be 45 years old or older. In the United States today there are more than 13 million people aged over 60, of which more than 9 million are 65 or older. The rate at which longevity is increasing was accelerated in the last census decade: from 1930 to 1940 our total population increased 7.2 percent, whereas the number of people 65 or older increased 35 percent in the same interval. The war will probably not alter the general trend significantly; deaths from battle casualties are counterbalanced by the quickened birth rate.

These trends were reflected in Industry well before the war. In the late 1930's one immense manufacturing corporation observed that the average age of its employees was increasing at the rate of a year per year. The shifts in population structure will continue after the war, and Industry needs to plan now how to best utilize the growing reservoir of potential accomplishment of the elderly. That they are capable of significant accomplishment is being demonstrated everywhere today. The tremendous withdrawal of young men from the farms and factories into the armed forces and the demand for gigantic production of the matériel of war has brought back into employment untold thousands of workers previously discarded as "too old." Just how many I do not know, nor does it matter greatly. Significant, however, is the undeniable fact that these older men and women, many far past later maturity and already in the years associated with senility, are laboring mightily, seriously, and effectively. Study of their production records will surely reveal that the former fearful attitude of management toward hiring employees past "the prime of life" was based more upon prejudice than factual data.

We cannot escape the obligations imposed by the ever increasing proportions of the elderly in our population. The elderly are here in unprecedented numbers, which will increase. If society fosters research and medical and hygienic practices for the prolongation of life, society must assume at least some responsibility for the lives thus extended. Certainly no one but another paranoid would advocate solving the problem, à la Hitler, by wholesale "liquidation" of the elderly. Business has but two alternatives: either to find and apply ways of employing older individuals in occupations and under conditions suitable to their peculiar capacities so that they may continue to earn their way, or to contribute more and more heavily toward payment of the mounting bill for their support, either directly as pensions, or indirectly and more expensively through heavier and heavier taxation for a "security" program already known to be actuarially insecure. The sane choice is obvious. We can expect little opportunity for individual saving for retirement in the face of present and impending taxation.

This is a gloomy picture, but as such is not a true one, for like the conventional cloud there is a very hopeful silver lining. The millions of people past their assumed "prime" constitute an invaluable, though previously ignored, human resource. They represent an immense potentiality of useful and creative accomplishment. Wise planning and guidance based on the growing scientific knowledge of the phenomena of senescence can develop their potentialities and minimize their limitations. The discoveries of pure science and their technological application, enthusiastically and profitably supported by Industry, have produced many previously unknown and often unsuspected forces and materials. These promise incalculable benefit to all. But the full development of man himself, in contrast to the physical world about him, has barely commenced. The wonderful potentialities of mankind can be discovered only in those fully mature. More men are growing old enough to think. Thus the alternative to economic chaos consequent to a growing population of unemployed and dependent senescents is the possibility of a splendid

cultural advance led by the wisdom of mature minds.

Obviously, Industry does not stand alone in being responsible for the solution of the general social problems created by increasing age. But industrialists, and particularly those executives concerned with personnel management, are in a uniquely advantageous position to lead the way. If Industry does not take the initiative soon and earn leadership by right of accomplishment, politicians will and chaos threatens. Once politicians discover the growing power of the vote of the elderly, we may anticipate legislation of a series of Utopian "schemes," each one wilder than those preceding and each calculated to purchase political support but blissfully ignorant of sound economy. There is also a dreadful hazard from the unscrupulous Bosses of labor, ever willing to obstruct honest effort. And honest effort is characteristic of senescent individuals, for the greatest tragedy and hurt of aging is the sense of uselessness when their services are discarded by society.

Industry thus has the powerful motivation of self-defense to exert itself in leading the way toward wiser utilization of the aging through development of their latent capacities and through energetic efforts to improve their physical health and effectiveness. Whether industrial leaders have the wisdom to encourage such efforts is a different question which only time can answer. Certainly the basic prerequisite to progress is comprehension of what the changes of senescence do to men and women. The general ignorance concerning the fundamental consequences of this universal phenomenon is sadly apparent. When we apply Artemus Ward's definition of ignorance as "not not knowing but knowing so many things that ain't so," the situation becomes downright dangerous. Let us not forget that we *all* age, whether we like it or not, and that senescence affects everyone who survives long enough.

### What Aging Does

Aging is a part of living. To age is to change. The changes consequent to aging start at the moment of conception and continue until death. The rate of change is greatest in infancy and youth and diminishes continuously as we approach the limits of man's span of life. Each period of life reveals certain characteristics peculiar to the age. The man of 50 is not the same person he was at 30—he is not merely 20 years older. He is a different being, with distinct alterations in his body structures, functional capacities, and reactions. He will continue to change, though more slowly, from 50 to 60 and still more slowly from 60 to 70. Just as the child is not merely a "little man," the senescent is something more than just an "older man." The changes involve all the innumerable activities which constitute living. People of different ages do not think alike, they do not react to disease in the same ways, they vary in their vulnerability to adverse environmental conditions, and differ in their capacity to work.

It must be re-emphasized that the changes occurring during senescence are not all in the direction of diminishing efficiency, as is commonly assumed. Certain functional capacities increase as others decline. The rate of depreciation with age of different structures and functional reserves is decidedly variable. We do not age symmetrically. I am sure we all know of some old men with young ideas; physicians see many young men with old hearts. As muscular strength and speed of movement diminish, certain manual skills may improve with continued use.

Furthermore, no two individuals age precisely alike. Chronologic age, as measured by the calendar, must not be confused with biologic age, for the two are often widely divergent. People do not all live at the same rate. The rate of aging is determined by the rate of living. Biologic time does not necessarily parallel solar time. Thus among any group of fully mature individuals there are some who have aged prematurely and others who are both physically and mentally much younger than their chronological age would indicate. Unfortunately, the latter are in the minority, although most of us are convinced that we are ourselves younger than our years. But this is wishful thinking and careful analysis would find many of us older than our calendar years. Variability among individuals increases with age.

One of the major reasons for the increasing variation among individuals is that no

two people lead identical lives. Each has been subjected to different physical and mental insults, fatigues, infections, and intoxications in different sequences and in varying intensities. All the apparently minor vicissitudes of existence affect us and their cumulative effect is most significant. What we are today is greatly determined by what we did yesterday and what happened to us the day before yesterday. Youth has had few yesterdays and therefore reveals relatively little variation.

This is not the place to discuss in detail the physical and functional changes which take place in senescence. Certain superficial and obvious changes we all know. Gray hair, bifocal spectacles, wrinkles, and a less steady walk all of us can recognize as signs of aging. But these are superficial and insignificant changes. Our real concern is with the efficiency of the organism as a whole. There are many young eyes, not requiring lenses, which see very little because they were never trained to look. What goes on within the skull is more important than whether the roof be a polished dome or a shaggy thatch of hair. As age advances speed and brute brawn diminish. But another and valuable characteristic, endurance for the slow grind, increases. Youth wins the sprint races; marathons are won by what sport writers dub "old men." It is significant that our army training programs have shown it to be more difficult to develop endurance in "trained" athletes than in farm boys, or men from the mines, desks, and factories. Industry too needs men able to maintain a steady but not flashy pace. Appraisal of productive capacity is not simple or easy, and judgments based on superficial signs are often sadly fallacious. Man has many capacities and thus there are many mental as well as physical facets relating to evaluation of fitness.

The major hazards from disease in youth and early maturity are quite different from those encountered in late maturity and senescence. Though many diseases appear in persons of all age groups, the more common, more serious, and more disabling disorders of the two periods are of entirely different character. In the first half of life almost all sickness arises from without, either from infection or physical injury. These disorders begin abruptly, are florid and therefore readily discovered, and are characteristically self-limited. In most instances the causative agents are known. Thus specific measures for prevention or treatment are possible. The tremendous reduction in morbidity and mortality among the younger portion of our population, which has contributed so largely to the dramatic increase in life expectancy in the last fifty years, stems from these very characteristics noted above. Because the sources of most illness to which youth is vulnerable lie in their environment, "wholesale" measures to improve the environment have immensely reduced the frequency of disease. Modern sanitation, quarantine to protect individuals from contagion, and the significant developments of industrial hygiene have thus changed the pattern of the population. All those millions of children and youths who now do not die of diphtheria, small pox, typhoid fever, tuberculosis, and similar infective diseases have the opportunity to survive to senescence.

As senescent individuals they become vulnerable to entirely different disorders. The common health hazards of later years are characteristically endogenous; they arise from within and not from environmental factors. They are chronic, silent of onset, and characteristically progressive rather than self-limited. They do not tend to subside of their own accord as do the acute infections of youth. Control of environment, either in the home or at work, can have but little effect on the frequency and severity of such disorders as arteriosclerosis, diabetes, heart disease, cancer, or arthritis. Prevention and control of these disorders must be on an individual basis and not through "wholesale" measures. There is no anticipation that we may ever be able to prevent high blood pressure by quarantine or reduce the frequency of diabetes by sanitation.

Two aspects of the so-called "degenerative diseases" of senescence are worthy of special emphasis. In the first place their occult and insidious beginnings make for delay in diagnosis and therefore in the institution of treatment. To discover hypertension or diabetes early enough so that treatment is attended by maximum benefit, they must be hunted.

The rash, fever, and sore throat of scarlet fever are violent and noisy signals of trouble. It takes little skill to discover such acute illnesses. But degenerative disease begins slowly, often without subjective symptoms, until irreparable and irrevocable damage is done. Secondly, the characteristic of progressiveness of these disorders is profoundly significant. Though progression in hypertension, arthritis, and arteriosclerosis is often very slow, it is always persistent. As a result, progressive and prolonged disability is the common sequence. Mortality figures can be badly misleading. For example, arthritis rarely kills, but it disables millions for many years. The arthritic becomes partially disabled in his late forties and lives on for twenty or thirty years, increasingly helpless, pathetically useless, and a constant drain on both his family and society. The economic aspects of chronic, progressive disease constitute one of the most urgent reasons for energetic attack upon the health hazards of later maturity.

## Industry's Concern

Industry's concern with these particular facets of the broad problem is twofold: it must recognize the importance of early discovery of progressive disease in older persons and assist industrial medical services in such discovery; and it must realize that before severe disability makes continued employment impossible, there is usually a long period of impaired efficiency, which may arise so insidiously that it is not recognized. Mild chronic illness is a significant element in the important problem of sick absenteeism. Continued assignment of responsible tasks to individuals gradually becoming more and more unfit to perform them introduces a double hazard; for the individual it creates stresses which tend to accelerate his depreciation and for Industry it invites expensive failures in performance. Many business disasters could be traced to arteriosclerosis in executives. On the other hand, the early discovery and prompt institution of proper medical management of diabetes may conserve for Industry many a fine, precious, and useful mind.

Industry is in business to earn money. This means that it is interested in saving money too. Industrial health programs are not primarily altruistic. They are basically concerned with reducing the heavy costs of injury to personnel occurring in the course of employment and checking the loss of production from absenteeism due to illness arising independently of work.

The first leak is being reduced through the triple activities of industrial hygiene, safety programs, and more effective medical and surgical repair and rehabilitation services. The second leak is the more serious, although its importance has been appreciated only recently. In loss of time, and therefore in loss of production, sickness absenteeism of nonindustrial origin is about fifteen times more serious than injury arising from employment. But basing loss from impaired health only upon actual absenteeism reveals only part of the picture. Probably equally expensive are the additional and unmeasured losses in production due to impaired efficiency of personnel not sick enough to be absent but who accomplish but a fraction of what they should be capable of doing if their health were optimum. For every employee absent because of illness, there are probably a dozen present who, because of impaired health, merely go through the motions of doing something. Among these are the conscientious fools with acute respiratory infections, generously spreading infection among their co-workers. Included also are many with chronic unrecognized and untreated disorders. In general the frequency of impairment, as measured by reduced effectiveness, is in inverse proportion to the severity. The ways and means of discovery and correction of the minor, early, chronic impediments to full vigor, health, and efficiency are closely related to and parallel those procedures required for the full utilization of senescent individuals. It will be worth while to remember that the implications of the concepts to be suggested in the remainder of this article are not limited to older persons.

(*To be concluded*)

# THE FENCE*

By HOWARD B. ADELMANN

It is with some trepidation that I, a worker in the sciences, venture to address you, my friends and colleagues on the humanistic side of the academic fence. Ordinarily, by an unwritten, but unfortunately, too widely observed agreement, you "humanists" cultivate only the fields on your own side; we "scientists" labor only on the other. Standing on my side of the fence, I have often hung upon it in friendly converse with you, and I have enjoyed the experience so long as I felt myself protected by that intangible barrier. But now that you have lifted me bodily over it, so to speak, by inviting me to come among you, my emotions are confused—on the one hand I feel the pleasure and the satisfaction of more intimate association with you, and on the other, I am fearful of exposing my inadequacies.

Unlike that distinguished but lovable gentleman, Hieronymus Fabricius of Aquapendente, who was three centuries ago Professor of Anatomy and Surgery in the University of Padua, and in whose company I have spent, most pleasantly, much of my time these past few years; unlike him, I say, I do not dare to promise you, as he once promised an audience, a discourse *absolutissima, fructuosissima, luculentissima.* His listeners went away muttering *imperfectissima, obscurissima,* and so indeed may you, despite the fact that I make no promises. At any rate, you will probably say with perfect justice, as his students did of some lectures they forced Fabricius to give: *ut coacta, ita admodum exigua;* which means, as you all know, "being compulsory, it was therefore pretty thin."

I was very glad to learn a few years ago that the Cornell Chapter of Phi Beta Kappa had decided to admit superior students whose interests lie predominantly in the laboratory sciences. Who knows? Perhaps the fence is being torn down. It did not always stand; its construction was begun long ago when a few scholars commenced to work intensively in the natural sciences, and, after both sides had worked at it diligently for some two centuries, it had reached by the nineteenth very nearly the proportions of a spite-fence. It should never have been erected; it was illegal to begin with, and unsightly and unneighborly at best.

The restricted application of the term "scientist" to workers in the natural sciences and mathematics, as is the common practice these days, is inaccurate and unsound, historically and linguistically. By what right have some scholars been dubbed scientists, a name which implies that they alone have the key to knowledge? By what right have other scholars been called humanists, a name which implies that they alone are the custodians of the forces that make a man more humane, more civilized, more exalted? There is, in truth, no essential difference in their aims: both strive to reach an understanding of man and the world he lives in; neither is the exclusive custodian of civilization, culture (or whatever you choose to call it), or of knowledge and the means to obtain it. Both may, indeed, sometimes use the same methods. "It is simply the fact," I quote Professor Lane Cooper, "that reduced to the simplest terms, there is but a single method of investigating the objects of natural science and the productions of human genius. We study a poem, the work of man's art, in the same way that Agassiz made Shaler study a fish, the work of God's art; the object in either case is to discover the relation between form or structure and function or essential effect."

And neither the so-called sciences nor the so-called humanities are by themselves adequate for man in his pathetic attempt to understand himself, his fellow man, or the world he lives in. The knowledge that I am made of organs, tissues, and cells; that these in turn are composed of carbon, hydrogen, oxygen, nitrogen, and a miscellaneous assortment of other elements, themselves

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owing their properties to the configuration of their atoms, electrons, protons, and neutrons is illuminating, even inspiring in its way. But it is not enough. Will Einstein's treatise on relativity increase my wonder at the magnitude of the universe? If I am moved by the grace and beauty of the flight of a bird will my exaltation be sustained by a handbook of the birds of central New York, or, on the other hand, by some poet's insight? Will a so-called "scientific" treatise on art explain the emotions aroused by beauty in whatever form?

My fellow man—will so-called science explain him completely? Must I not also, at the very least, have some knowledge of his language, his literature, and his history?

And the universe—can science explain it all? I ask *you*. At the present time the hope that both camps working together will some day explain the universe even partially seems almost presumptuous.

The truth is that a diet of straight science is unsatisfying. Karl Ernst von Baer, whom we honor as the founder of modern embryology, and who, like most great men, was modest, tells of his experience after he had labored for the better part of a year, shut up in his laboratory, at his studies on the development of animals. He had started work when snow lay upon the ground, and when he finally emerged from his self-imposed imprisonment he found the grain in sheaves. "This sight moved me so deeply," he says, "that I threw myself upon the ground and reproached myself for my foolish behavior. The natural laws of development will ultimately be discovered . . . whether by me or by others, whether this year or at some future time is relatively unimportant, and it is utter folly to sacrifice to this end one's own joy in Being which no one can replace."

We scientists, I think, are peculiarly apt to lose our sense of proportion. We describe a bug not previously recorded; we make an experiment never performed before; and our discoveries are so exhilarating that we are apt to magnify our own importance, and like Aesop's fly resting on the axletree of a chariot wheel, marvel at the cloud of dust we raise. We need the corrective of history and literature, which gently teach us our proper place. The scientific journals of yesterday are gorged with the papers of scientists who were no doubt "big" men, "productive" men in their day. One imagines that they were deluged with "offers," and that they basked in the prestige that loquacity in print often brings. But they are unknown to fame; the once mighty have fallen. It is no discredit to them; they have contributed their mites.

On the other hand, it is encouraging to know that the humble sometimes rise. Think of Gregor Mendel, regarded, perhaps, in his day as a harmless putterer in the monastery gardens at Brno, and now paid tribute as the founder of modern genetics.

Now whether or not the humanities undefiled are an adequate diet for the mind, you will know better than I. I shall merely ask, and having said *peccavimus* for the scientists, leave you, if it is in your heart, to do so for the humanists.

As I have said, the imaginary fence between the scientists on the one hand and the humanists on the other did not always stand. In what I like to think of as better days, philosophy, art, and science were not differentiated. The emphasis then was upon knowledge, and all departments of knowledge were called upon to contribute their fair share to a unified system aimed at the comprehension of all phenomena.

The works of Aristotle, for example, contain something of value for workers in almost every field of knowledge. For some of you he is one of the greatest authorities in the art of poetry, others of you have, no doubt, found much of permanent value in his works on rhetoric, ethics, politics, logic, or metaphysics. As a biologist Aristotle has had his detractors, but for me, as for others, he is the greatest biologist that ever lived.

D'Arcy Thompson, a classical scholar as well as a scientist, says that Aristotle seems to have been "first and foremost a biologist, by inclination and by training," and Jaeger, a classical scholar, indicates that Aristotle's true genius lay in the field of biological science. It is, at any rate, surprising to find how large a part of his writings deals with biological problems, a fact sometimes overlooked by those who are interested in other aspects of his work.

Some scholars believe that the zoological works were composed during the period of Aristotle's second stay in Athens, say a dozen years preceding his death. Others, however, believe that the philosopher's biological studies were begun at Lesbos about ten years before he began his teaching in the Athens Lyceum. And the evidence does seem to show that his most important observations were made on the Asiatic coast and in the vicinity of Mitylene on Lesbos.

There are three aspects of Aristotle's biological works upon which I should like to touch briefly—first, the range of his zoological knowledge; second, his profound grasp of the essential problems; and third, his method of investigation.

Aristotle was acquainted with a truly astonishing number of animal forms. Some of them, particularly marine animals, he knew rather intimately, others only superficially. Some he appears to have dissected, others he peered into as we do in preparing a fish or a fowl for the table. When I say dissected, I do not mean that he dissected systematically or thoroughly—he would, no doubt, have done a better job with a modern manual for dissection at hand. He came to the study of animals untutored; many structures he overlooked, and many he misinterpreted because his mind and eye were not prepared to grasp the significance of everything he saw; but on the whole his knowledge is of such a character that it is difficult to believe that all of it was derived from talking with fishermen, hunters, or butchers, or that he was merely a passive observer of work performed by students.

D'Arcy Thompson marvels at Aristotle's rather intimate knowledge of marine molluscs, and, as many others have done, calls attention to one remarkable observation which was not substantiated until the nineteenth century, after several observers had completely misinterpreted the true state of affairs. In both the *Historia animalium* and the *De generatione animalium* Aristotle describes the peculiar transformation of one of the arms of the male octopus into a sperm-bearing organ which is detached after it is placed in the mantle cavity of the female. This detached arm was rediscovered in 1828, called a parasite, and given the scientific name *Trichocephalus acetabularis.* Later, Cuvier described it as *Hectocotylus octopodis.* Kölliker, the distinguished Würzburg anatomist, regarded it as a parasitic male similar to the diminutive males found in certain other animals, and it was not until 1851 that the French naturalist Vérany fortunately discovered that the supposed parasitic male is really one of the arms of the male octopus. Finally, in 1894, Racovitza's observations on the mating of the octopus completed the confirmation of Aristotle's description.

Aristotle's knowledge of fishes is another aspect of his work that has aroused the admiration of commentators. For example, his description of the various types of cartilaginous fishes, that is to say, the sharks and rays, was a real achievement. He knew that some sharks lay eggs and that in some the eggs are retained in the oviduct of the female until the young fish are ready to fend for themselves. Until it is able to capture food an embryo shark lives upon the yolk stored in the egg; this yolk is contained in a sac, the yolk sac, which is attached to the intestines of the embryo by a long stalk, called the yolk stalk. Aristotle knew this, and he knew, further, something that zoologists did not generally know until 1840. He tells us that in the smooth shark the young develop with the yolk sac attached to the wall of the oviduct, "so that as the egg-substance gets used up, the embryo is sustained to all appearances just as in the case of quadrupeds." In other words, Aristotle recognized the placental character of this union of the yolk sac with the oviduct or uterus. At the point of contact the embryonic and maternal tissues are highly vascular and inter-folded so that an interchange of substances between mother and fetus becomes possible. Such an arrangement is now called a yolk-sac placenta, to differentiate it from the type of placenta found in mammals. In some mammals, however—the horse, for example—a yolk-sac placenta essentially similar to that of the shark's is found in addition to the usual type.

Aristotle's observation of the yolk-sac placenta of the shark was confirmed by the great Danish scientist Niels Stenson in 1675, whose description was published in a

relatively obscure journal, the *Acta medica et philosophica* published at Copenhagen. Buried there, Stenson's contribution was completely overlooked, and it was not until 1840 that Johannes Müller again called attention to Aristotle's original description and confirmed it by his own investigations.

As an embryologist, I am naturally interested in Aristotle's account of the development of the chick. I shall not tire you with an analysis, but say merely that it is the work of a really acute observer and a highly creditable achievement.

There is no time to continue this sketch of Aristotle's knowledge of fact, nor can I discuss in detail his attack on the major problems of zoology. He did think wisely and soundly about many of the fundamental issues; but obviously it would be stupid to expect solutions of them, or twentieth century analyses, from an author who lived so close to the very beginnings of scientific endeavor. We are still working at the answers to almost all of them.

One of Aristotle's theories, however, shows so clearly what E. S. Russell calls the "sheer intellectual power" of the man that I cannot pass over it. That he was able to formulate, in the necessarily imperfect state of his own knowledge, a theory of development that conforms closely to our modern point of view is, I think, noteworthy. He rejects the idea that the embryo is preformed from the moment of conception and argues brilliantly that the parts of the embryo are only gradually evolved as development progresses. This so-called doctrine of epigenesis is usually associated with the name of William Harvey, the discoverer of the circulation of the blood, but Harvey obviously was indebted directly to Aristotle.

And now a word about Aristotle's method. The biological treatises reveal a complete shift of emphasis in contrast to the others. In his earlier works Aristotle emphasizes the deductive, syllogistic approach to knowledge, but in his biological works he stresses the basic importance of observation, of observation as the starting point in the acquisition of knowledge. This change of emphasis has often been overlooked. The first of his three great zoological works, the *Historia animalium,* is essentially descriptive in character, dealing primarily with the material cause; the second, the *De partibus animalium,* elucidates the final cause, the good purposes displayed in the structure of animals; while the third, the *De generatione animalium,* is a treatise on the efficient causes of development, the forces which bring animals into being.

It is interesting to notice how this emphasis on observation and this general plan of treatment influenced later writers. Galen, for example, teaches as an invariable rule that one should dissect and describe before attempting to ascertain the action or the useful purpose of an organ. In his works on anatomy and physiology, Fabricius in the sixteenth century invariably stresses the importance of the same order of treatment and cites Aristotle and Galen as his models. Sir William Harvey, the pupil of Fabricius, quotes Aristotle as his authority in urging observation and admonishes us to trust nothing but our own eyes, to accept nothing not "securely bottomed by the faithful testimony of our own senses." "It is unsafe and degenerate," he says in the Preface to his *Anatomical Exercitations* in 1653, "to be tutored by other men's commentaries . . . when the book of Nature is so open, and legible. The ancient philosophers went quite a contrary way to work, and by in defatigable [sic] toile . . . have set up a clear light to direct our studies. So that whatever notable and approved thing we have in philosophy, it all is derived to us by the pains and industry of ancient Greece." And he further tells us that "in chief, of all the ancients, I follow Aristotle."

Now, I am no philosopher. I cannot argue for or against the validity of observation as the basis of scientific procedure. I only know the feeling of most present-day workers. If they were questioned, I am sure that they would, almost to a man, rightly or wrongly, scientifically or unscientifically, urge observation as the indispensable approach. And I know that it is easy to trace this emphasis on observation back through the years to the seventeenth and sixteenth centuries when many men thought, rightly or wrongly, that in urging observation they were following in Aristotle's footsteps. Thence the path follows back to the resto-

ration of Aristotle to Western Europe in the late Middle Ages.

In physics Aristotle's standing is not high; mathematics he virtually ignored. But, even in these connections, I wonder if too much has not been made of the so-called revolt against Aristotle—of the revolt of Galileo, for example, of whom J. H. Randall says, "in method and philosophy if not in physics he remained a typical Paduan Aristotelian." Francis Bacon justly attacked Aristotle's reverence for final causes, and his vision of a science based on experiment is a noble one. But listen to Bacon's statement in the *Sylva Sylvarum:* "Aristotle," he says, "giveth the cause, vainly, why the feathers of birds are of more lively colors than the hairs of beasts,—for no beast hath any fine azure, or carnation, or green hair. He saith it is because birds are more in the beames of the sun. . . . But the true cause is that the excrementitious moisture . . . passeth in birds thru a finer and more delicate strainer than it doth in beasts; for feathers pass thru quills, and hair through skin." Hardly an improvement on Aristotle's explanation!

It is, as both Olschki and Randall have noted, probably a mistake to accept at face value "the estimate the pioneer thinkers of the sixteenth and seventeenth centuries made of their turning away from the heritage of the past."

I have dwelt on Aristotle as an example of a thinker whose interests embraced all knowledge. But I realize full well that we can never return to the day when a man could have respectable competence in a great number of fields. We cannot revisit yesterday, or ask even the fleeting moment to delay. Knowledge has grown too vast for one man to digest it all, and a minute knowledge of one field, indeed, of even a small corner of one field, is often difficult, sometimes impossible, to master.

Specialization can be, however, and has been, in some instances, carried too far and without tangible profit to the individual or to science. As in the past, catholicity of interest even today has its values.

I like to think of those physicians who in the fifteenth and sixteenth centuries did so much to restore the great texts of ancient learning to the enjoyment and profit of man—of Linacre, for example, the physician of two Henrys, VII and VIII. He was one of the first English physicians to study at Padua, the great stronghold of Aristotelianism. It is said that the noble Aldine *Editio princeps* of Aristotle was, in part at least, edited or corrected by him. When he returned to England he taught Greek and practiced medicine at Oxford. More and Erasmus were his students and so were two children of Henry the uxorious. He translated much of Galen into Latin. He was a distinguished grammarian, and Fuller, the historian, says that it "is questionable whether he was a better grammarian or physician." His masterpiece, the *De emendata structura Latini sermonis,* has been called "the first-fruits of English erudition." But Milton says, "Though very learned it is thought not fit to be read in schools." What an apt characterization of some contemporary texts!

Coming down the years, and ignoring many I might recall to you, I think of Albrecht von Haller, the great eighteenth-century Swiss from whose facile pen poured the first modern textbook of physiology; distinguished works on anatomy, surgery, embryology, and botany; bibliographies that are models not yet superseded; and finally, poetry that is still admired, for editions still come from the press.

In our own day there was Sir William Osler, Professor of Medicine at McGill, Pennsylvania, and Johns Hopkins, and from 1905–19 Regius Professor at Oxford. He was the author of one of the first literate textbooks of medicine, and the world was amazed that a physician could write the English language with lucidity and grace; amazed when he introduced into his discussion of tuberculosis the parable of the Sower, or quoted Sir Thomas Browne, or showed in any small way that he was familiar with something more than the bare bones of technical literature. And is that amazement not in itself significant? Osler loved the literary classics, was himself learned in them, and in 1918 was honored by election to the presidency of the Classical Association of Great Britain. Throughout his life the *Religio Medici* of Sir Thomas Browne was a constant

companion, and the copy he had bought as a boy was placed in his hands when his remains lay in state. In his essays he never ceased urging physicians to consult with the great minds of the past while they themselves pressed forward. His methods of medical teaching were unquestionably responsible for the reform which began to affect our medical schools shortly after 1910. His beneficent influence still persists, and no doubt lies back of the emphasis the officials of our medical schools now rightly place on broad cultural training in preparation for medicine. But, alas, they think that culture, so-called, can be acquired from formal courses in college! And, alas, too, they do not realize that they must themselves set an example. The teacher says, "Look at Osler." And the student, too often, unfortunately, can reply, "Yes—look at Osler. But you, dear teacher, are not an Osler, and yet, by specializing narrowly, you have acquired a far larger share of this world's goods than he. Rumor says that you clean up an appalling sum in private practice, and this advice to shun the fleshpots, to cultivate the gardens of the soul, comes ill from you."

And in the so-called pure sciences a teacher who admonishes his students to acquire even so elementary and useful an accomplishment as the ability to read a modern foreign language without too frequent recourse to a dictionary is, as likely as not, met with the retort: "Look at Professor Gamma. He reads French and German with, to put it as kindly as possible, the greatest of difficulty—I know, because I took my language exam for the doctorate from him—yet he is respected as the world's greatest authority on the tenth cranial nerve of Ornithorynchus."

How can one reply without transgressing professional ethics?

Convincing the modern gradute student of (let's say) histology how important an asset some historical knowledge might be, or teaching a little history of biology along with modern developments, takes a deal of persistence, even bravery, under present circumstances. And, yet, I think we scientists must begin to teach in our classrooms respect and sympathy for those disciplines that now are often regarded as foreign to our interests. We must do it by calling upon philosophy, history, and literature where they impinge upon our work. I know of no department of science where such treatment would not stretch the vision and deepen the understanding.

And now, dear humanistic scientists, how about a little natural science in *your* classrooms? How about the history of science? How about some Hippocrates, Aristotle, and Galen in Greek? How about some Latin from the scientists of the sixteenth, seventeenth, or eighteenth centuries; in French, some of Pascal's scientific, in addition to his purely literary, works; or in German, let's say the autobiography of Karl Ernst von Baer? I think I know at least two good objections you may raise—lack of time and the lack of literary merit in some of the works I mention. But can you not compromise? It would, I think, be for your good as well as ours.

This war is going to send our young people back to you in larger numbers than of late. They are going to return to you surfeited, sick unto death of technological and scientific detail. They will, many of them, thirst after the good things, the human values, you can offer them. There lies the chance you may seize to the everlasting benefit of us all. In this modern world, however, no man can well get along without an awareness of the great technological and scientific advances of our age. We must work together to destroy the fence that has, to our common disadvantage, kept us apart, or at least provide friendly and inviting portals through it. It is for us both to show the student that the humanistic and natural sciences together form a part of the heritage he ought to embrace in justice to himself and for the good of the world.

# MIRACLES? . . . MAYBE

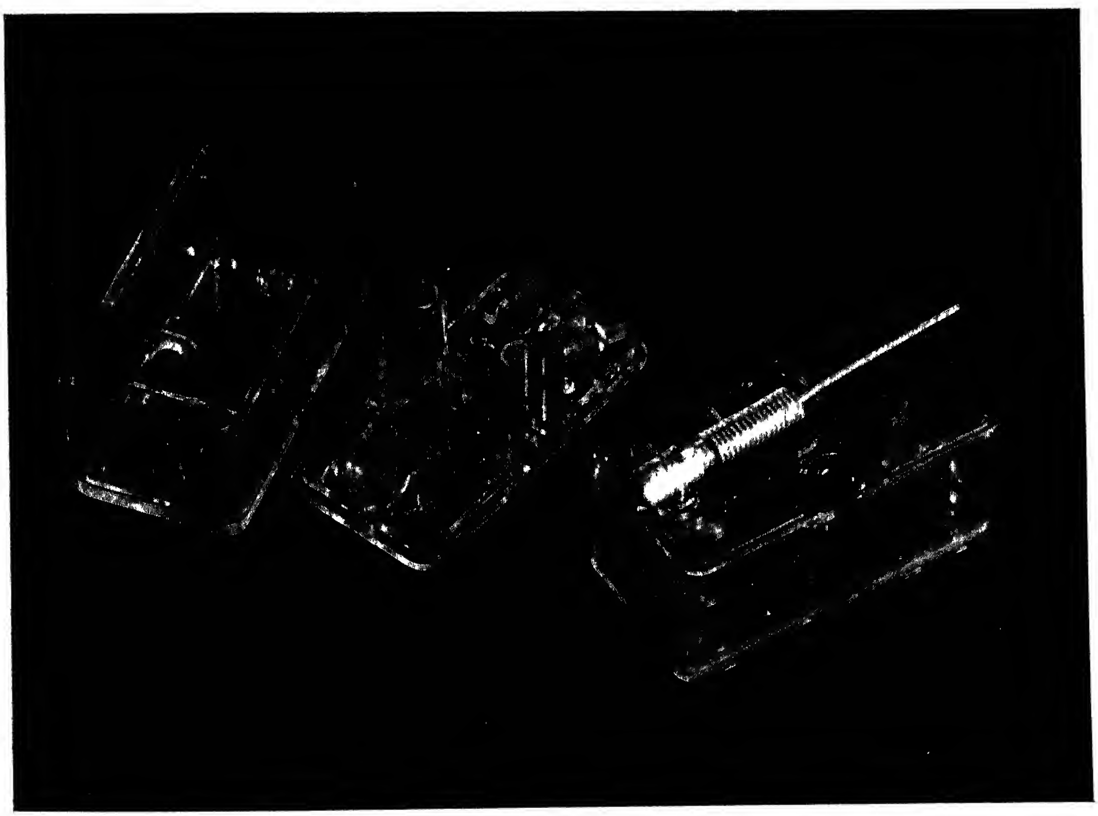
By L. H. WOODMAN

"PLASTICS will revolutionize living." "A miracle age of plastics is just around the corner." "In the plastic world ahead many common metals will become obsolete."

Whether such statements, which are unfortunately typical of many seen and heard from day to day, represent an attempt to startle the public mind to attention through the inherently magnetic power of the fantastic, or simply misguided over-enthusiasm is a moot question. It is certain, however, that they do not represent the real opinions of sound-thinking designers and engineers, nor of the dozen or more reputable companies which are now supplying the major portion of the plastic materials being produced in this country

First of all let us see what plastics are and from whence they come To the average individual the term may well bring to mind a gadget purchased in a variety store, a piece of costume jewelry, or the streamlined cabinet of a small radio. He does not necessarily associate the term with high quality; in fact he may well regard articles made from plastic as ersatz—something to be worried along with until more common materials are once more obtainable. He has, however, been quite thoroughly educated to expect that in the months following the war a host of new materials, little short of miraculous in their beauty and qualities, will make their appearance.

To the chemist, these materials, which for the most part have their origins in coal, petroleum, brine, or vegetable fibers, represent



TRANSPARENT SWITCH BOX MOLDED FROM POLYSTYRENE
ITS EXCELLENT ELECTRICAL PROPERTIES RECOMMEND IT FOR SCORES OF POWER AND RADIO APPLICATIONS.

PLASTIC-COVERED CHAIR
*SARAN* RATTAN AND FABRICS FROM FINER FILAMENTS PROVIDE DURABLE UPHOLSTERY FOR MANY PUBLIC USES.

a fruitful field of exploration for years to come—a field holding great promise both for the improvement of formulas and methods for making existing plastics and for the discovery of synthetic materials not yet envisioned by even the most imaginative chemist. This is apparent partially because many plastics are polymers.

Polymerization is a term applied to the linking together, in a definite pattern, of two or more molecules of a substance (monomer), resulting in a chemically identical but physically different substance. Since each polymer containing a different number of molecules in linkage, or perhaps the same number of molecules but linked in a different pattern, may possess unique properties, it is seen that literally millions of such polymers are possible. This does not mean, however, that millions of plastic materials are conceivable or possible, but it does indicate the field of exploration which is open to the chemist.

Commercial development of these polymers has been partially a matter of determining what stimulus was responsible for a particular type of polymerization and of learning to control that stimulus so that the same polymer would result each time it was applied. The stimulus may be temperature, light, pressure, various catalysts, or a combination of several factors. Of even greater importance in this development has been the achievement of consistent purity in the monomers from which these polymers are derived

Other plastic materials result from the compounding of two or more chemical substances under certain conditions, and here again is a broad field for future development

While plastics as structural materials are relatively new, crude or impure forms of some of these resins have been laboratory curiosities for many years. For example, the history of the vinylidene chloride polymers dates back as far as 1838 when a chemist named Regnault reported the formation of a white, noncrystalline precipitate from a liquid boiling between 35 and 40 degrees Centigrade. The liquid was apparently an impure dichloroethylene.

Later, about 1872, other experimenters found a similar substance which polymerized in light to a white, amorphous mass, which was found to be insoluble in many solvents. Extensive work on these polymers, however, has been limited to the last decade, and this family of resins known as *Saran* was not introduced to the plastics industry until 1939.

A similar history is found in the case of crystal-clear polystyrene. The styrene monomer was first isolated in 1831, having been produced from the distillation of a purified form of balsam known as storax. Its

TRANSLUCENT *SARAN* TUBING
ADVANTAGES OF THIS TUBING OVER COPPER AND OTHER TYPES ARE FLEXIBILITY AND CHEMICAL RESISTANCE.

thermo-polymerization in the presence of sunlight was noted some eight years later, but it was not until 1869 that the ethyl benzene process for making styrene was discovered by the French chemist, Berthelot.

The first recorded patents disclosing possible uses of styrene were granted in 1911 to F. E. Matthews of London, who observed the excellent insulating qualities of polymerized styrene. In the succeeding years polystyrene molding powders gradually gained popularity in Europe. In 1937 The Dow Chemical Company introduced *Styron,* a high purity polystyrene, in this country after years of intensive research in developing a controlled production process which assured uniformity and overcame certain other major obstacles that had held back the commercial development of these resins.

Such case histories are by no means rare among these so-called *new* plastic materials. Like many modern chemical finds, they have resulted in their present form not from scientific hocus-pocus or chance discovery, but rather from the painstaking, but imaginative, research of several generations of scientists.

That the product of such efforts in many cases should have been introduced to the public in the form of trinkets, or in applications where the properties of the plastics could not be fully utilized, is somewhat regrettable. Polystyrene, for example, is one of the most efficient organic electrical insulators

UNAFFECTED BY ACIDS
THE LADLE BEING USED IS MADE OF *SARAN,* ONE OF THE MOST CHEMICALLY-RESISTANT OF ALL PLASTICS.

ever discovered. This property alone is of vast importance to radio, power, telephone, and allied fields. But it has many other admirable characteristics. It is among the lightest of all plastics, having a specific gravity of only 1.06. It does not absorb water and is highly resistant to most acids and alkalies. It can be produced in all colors of the rainbow or in such crystal clarity that optical lenses are being made from it.

Obviously, polystyrene makes an exquisite string of beads or a beautiful lamp base, and there will be plenty for such uses, but its characteristics portend many more important applications. It will add beauty to our lives through purely decorative functions, but it has a far greater destiny in adding safety, comfort, and convenience through applications that will be less apparent but more fundamental in their importance. The styrene monomer itself is at present a vital component of Buna S, a synthetic rubber.

*SARAN* THERMOPLASTIC PIPE
A PIPE BASKET FABRICATED FOR USE IN PICKLING BATHS FOR SURFACE FINISHING OF MAGNESIUM PARTS.

So it is also with *Saran.* This versatile family of resins appears in an amazing number of forms—as a chemically-resistant black pipe, or a yellowish, translucent, flexible tubing; as a clear, tough, moistureproof film; as a spongy, rubberlike substance that may in

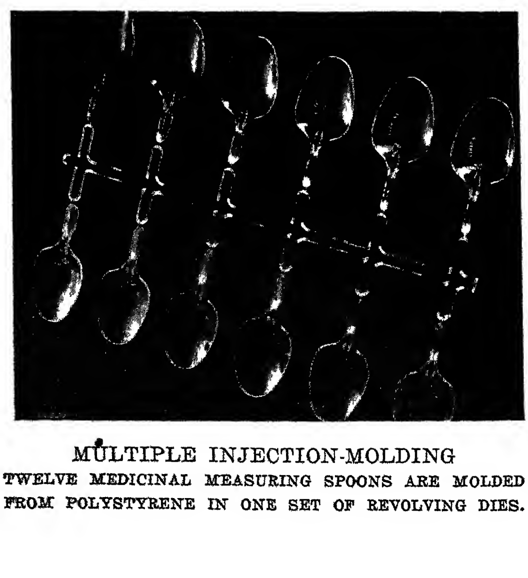
HYGIENIC *SARAN* INNERSOLES
MADE OF LAYERS OF SCREENING WELDED OR SEWED AT EDGE, THEY ARE RESILIENT, NONABSORBENT, WASHABLE.

the future be used for shoe soles, tubing, perhaps even tires or inner-tubes; as a colorful, moisture-resistant, long-wearing fabric; as a variety of molded or extruded shapes; as a flexible screening material that will neither rust nor corrode.

Like polystyrene, *Saran* has its decorative applications. Before the war, belts, suspenders, and other clothing accessory items were woven from colorful monofilaments of the material. As a matter of fact, *Saran* made very good belts and suspenders, but its properties cast it in far more vital roles. Since is it one of the most chemically-resistant plastics, it will be widely used in forms such as pipe and tubing to replace copper, steel, iron, and other metals in a host of industrial applications where chemical action upon the metal has previously made frequent replacement necessary. As a film it now protects machine guns against damage by moisture during shipment; in the future it will lend this protection to foodstuffs, clothing, metal parts, and equipment for civilian use. As a synthetic rubber it may find ready acceptance for use under conditions which deteriorate natural rubber rapidly. As a colorful fabric it will lend its exceptional wearing qualities to upholstery materials for automobiles, theater seats, bus and train seats, and other installations where excessively hard use is encountered. As a screening material it will add beauty, cleanliness, and convenience to the home, factory, or public building.

These are thumbnail sketches only, and when it is remembered that there are already more than a dozen basic plastic materials of proven worth, many of which have multiple applicative personalities, the tremendous scope of these products of chemistry may be appreciated. If we attempt to say, however, that plastics will completely revolutionize living, speak of them as "miracle" materials, or suggest that common metals will become obsolete, we are making bold and probably fanciful predictions. For countless uses the older materials will continue to remain the most suitable, and only where a plastic can prove itself more advantageous than any other material can it hope to gain and maintain precedence in the field of public acceptance.

Plastics are not cure-alls or all-purpose materials any more than are wood, glass, leather, or steel and other metals, and they are subject to the same tests of worth. In considering a plastic as opposed to a nonplastic material, and in selecting from the many types of plastics available, the industrial engineer must ask the same time-tested questions: What is the cost of this raw ma-



MULTIPLE INJECTION-MOLDING
TWELVE MEDICINAL MEASURING SPOONS ARE MOLDED FROM POLYSTYRENE IN ONE SET OF REVOLVING DIES.

INSECT SCREENING WOVEN FROM *SARAN* MONOFILAMENTS
IT IS LIGHT, HIGHLY FLEXIBLE, RESISTANT TO CHEMICAL FUMES AND SALT AIR AND TO ATTACK BY FUNGI.

terial? What will be the cost of fabricating it into the finished article? Are there complicated production factors involved? To what extent will the use of this material necessitate the installation of new and expensive equipment or involve the acquisition of specially trained men? And finally, will the finished product, made from this material, be a better product for its intended use than a similar one made from another material? Or will it be equal in quality and performance and still enjoy advantages in the way of production economies?

These questions might be said to represent simply the major titles of the "examination." Within them are hundreds of minute technical questions. The acceptance or rejection of a particular plastic, or of plastics as a group, depends upon a careful weighing of the answers. Failure to consider all points involved, and in proportion to their relative importance, may well result in an embarrassing misapplication of a very worthy material.

Many plastics, for example, lend themselves well to the injection-molding process of fabrication. This automatic or semi-automatic process is an extremely economical production method. Plastic material is injected, through a mouthpiece or jet, into a set of dies. The dies are so made that from one to a dozen or more pieces may be molded at a single "shot," and several sets of such dies may be mounted in a revolving turret, so that while the molded pieces are being ejected from one set, the plastic is being injected into another set With such equipment the production of several hundred small parts per minute is readily accomplished.

In the face of such production economies it is apparent that there may well be some temptation to utilize plastics in applications

USING A PLASTIC CANTEEN
MADE OF ETHYL CELLULOSE, THIS CANTEEN IS LIGHT, ODORLESS, TASTELESS AND WITHSTANDS HARD SHOCKS.

for which they are not ideally suited. Correctly applied, however, these production economies open the door to a host of low-cost plastic articles which will equal or exceed in beauty, utility, and performance similar products made from more costly materials or by more expensive methods.

While war necessity may have forced certain plastics into applications where their performance is by no means exceptional, it is at the same time serving as a gigantic and stern proving ground for plastics of all types. A number of plastic materials have for some time occupied a position akin to copper, brass, steel, and other metals on the nation's "critical" list. With the broad range and exacting requirements of military plastics, the knowledge and experience being gained today should leave little doubt in the minds of those associated with the industry as to the correct and incorrect applications of most of these materials It will be the function of these men—the responsible manufacturers, designers, and engineers—to use this knowledge wisely in building the postwar plastics industry upon the substantial foundation of fact rather than on fancy and fadism.

These men know that plastics, properly applied, are truly amazing materials. But they also know that there never has been, and never will be, a material perfect for all purposes. Under competent development plastics are already graduating from the gadget stage into their rightful position as tools of industry and science in their continuous progress toward a better and higher plane of material civilization.

Miracle materials? Yes—if steel, glass, and cotton are also miracles. Each must have seemed equally miraculous when technology first brought it into view Revolutionize living? Probably to a considerable extent, but not necessarily in the spectacular manner that many people have been led to expect—at least not immediately after the war. Widely assorted plastic articles should be available in plenty, but the more spectacular proposals—plastic auto bodies, plastic houses, plastic flivver airplanes—if they come, will develop more slowly. Meanwhile, plastics will play their more vital role behind the scenes through industrial applications that will constitute unseen but determining factors in our evolution toward better living.

# THE FORBIDDEN LAND*

By MARY ELLEN GOODMAN

For the nomadic peoples of Tibet, life is chiefly regulated by the character and potentialities of their domestic animals. Their herds include sheep, long-haired goats, horses, and yaks. All save the last prefer to feed on grass in the stream bottoms; the indigenous yak wanders up the hill slopes after moss. He is a slow feeder and, when utilized as a pack animal, must be freed at night; as C. Suydam Cutting has remarked, the yak must be "allowed to wander at will, with the result that a good two hours must be spent in the early morning in collecting the yaks and loading them before a caravan can move." Although much slower than the horse—he travels about two miles an hour—the yak is ideally suited to the region because of his heavy coat and his ability to feed on limited materials and to carry packs of as much as a hundred and seventy pounds. In western Tibet sheep and goats are also utilized as pack animals. They carry twenty to twenty-five pound loads and may be slaughtered at the end of the journey.

The pastoralist moves with his animals when pasturage is exhausted and when seasons change. Maximum summer temperatures allow him to move north and west and to higher elevations, while with the dropping of the temperature he works his way down until in mid-winter, with his grain supplies nearly exhausted, he makes his way to Lhasa or another urban center where he may stay during the most bitter weather. Lhasa and Shigatse are the chief centers of trade in central Tibet; Cham-do, Tye-kun-do, Der-ge, and Ta-chienlu in eastern Tibet. According to F. Spencer Chapman, "These swarthy, independent-looking people come down (to Lhasa) from Amdo, Golok, the high, desolate Chang Tang, and the far Mongolian border. Many of them bring herds of yak and sheep with them, carrying loads of wool, salt (which they collect from the shores of the great brackish lakes), and yak dung." They may also bring hides, yak tails, butter (packed in animal gut), borax, musk, and the horns of a certain deer. They make their pilgrimages about the city, pay their respects at the shrine of the last Lama, and perhaps perform more arduous devotions; buy a year's supply of barley, wheat, tea, peas, woolen cloth, a few turnips and radishes; and enjoy the blandishments of urban life for a time. Even the Golokpas, who are said to be professional brigands in their own district, periodically issue forth and go peaceably and unmolested to trade in other areas.

Trade of this seasonal and individual variety is conducted in small awning-covered stalls set up along the streets and open generally only in the morning. Transactions are said to be completed by hand signals, pressures, and so on, inside the long sleeves of the negotiators. The bargain is sealed with good wishes all around. Though there is a regular mercantile class of full-time specialists, every one engages in trade occasionally. The nobility have commercial agents who go to Peking, Mongolia, and India to buy them rare and valuable things; the large monasteries trade widely; and the government has many "purchasing agents" throughout Tibet and in foreign parts.

While trade between Tibet and the "outside" is, by western standards, on a small scale, it is essential to Tibet. Hides and wool are the chief exports, while in eastern Tibet clarified yak butter is sold in large quantities to the Chinese. Borax, yak tails, salt, musk, ponies and mules, medicinal herbs, and gold dust also pass beyond Tibetan borders. Imports from China are, primarily, tea (fourteen to fifteen million pounds a year being consumed) and, secondarily, silks, satins, brocades, cotton goods, dyes, matches, buttons, and rare foodstuffs. Imported from India are cotton goods, woolens, hardware, coral, precious stones, tobacco, Homburg hats, dried fruits, sugar, molasses, and miscellaneous domestic utilities such as matches, needles, and soap. From Nepal and Bhutan comes rice. Two caravans a year pass between Lhasa and Mongolia, carrying out woolen cloth, incense, and Tibetan scriptures,

* Continued from page 356.

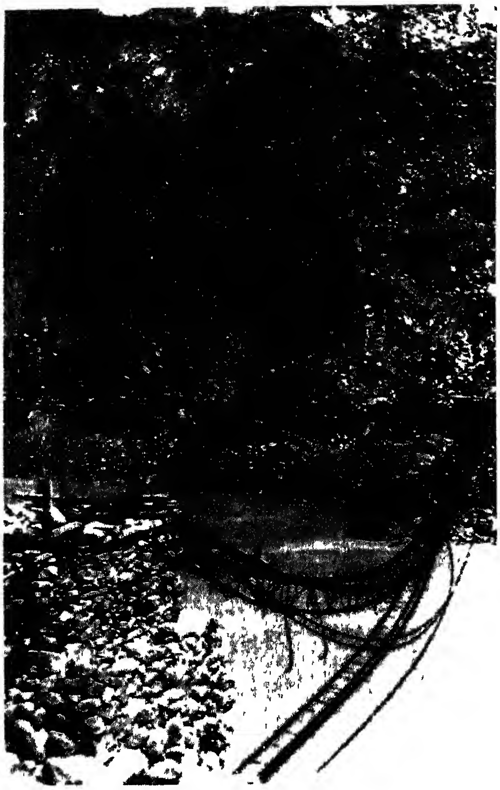


FIG. 11. WICKERWORK BRIDGE*
SUSPENDED ACROSS A GORGE IN WESTERN TIBET.

and bringing back Chinese silver, some gold, silk, and ponies. Tibetans are said to excel as caravan men, being able to pack expertly and to make long marches through inclement weather. Sino-Tibetan trade tends to pass more and more by water, Tibetan products often being floated down the Brahmaputra and other rivers (Fig. 11) to trade centers.

A part of Tibetan trade, both domestic and foreign, is in terms of cash, but payment in labor or commodities is still the rule, particularly within the domestic economic system. A landed proprietor will employ shepherds to look after flocks, which may amount to 20,000 sheep, under an arrangement that one lamb must be yearly added to the flock for every three sheep. Any deficiency must be made up, and any excess becomes the worker's profit. In addition, the owner supplies a small salary and salt for the sheep. Under another form of tenure the owner may specify amounts of yak butter, yak hair, and cheese to be produced per year, the excess being retained by the tenant. A proprietor may "let" the whole of an estate, the "lessor" taking subtenants who may pay him a fixed yearly sum in cash or grain, or who share equally with him the rent and the profits. The shepherd usually does not render unpaid services unless he combines farming with herding Government revenues are paid in commodities or cash, usually in the former. Taxes are fairly heavy, and the government may requisition supplies (as animals and porters for officials and others on government business) and levy extra taxes in case of war or other emergency Furthermore, noble families must supply two members for government work on nominal salaries or pay for a substitute. The taxes of a great family amount to nearly half its income. In case of need, however, mortgages on land and loans of cash or commodities, providing by contract the terms of repayment and interest, are made by the government, by individuals, or by the large monasteries.

While the tenant system implies frequent indebtedness and powerful ties of dependence upon the landlord, slavery is theoretically absent from Tibet and the employer-employee relation holds. In the Chumbi valley, where great prosperity has resulted from the passage of about half of the Tibeto-Indian trade, the natives employ servants from the interior to drive mule caravans and to perform household tasks. Wages paid are about twice as high as elsewhere. Landed proprietors maintain large servant staffs occupied not only in agriculture and grazing but also in spinning and weaving, in personal service, household tasks, and so on. Household servants are said to receive no wages. Where the "lord" commercializes fairly intensively on a given product, the "factory" may be a separate establishment on the estate in which live both male and female workers. They may devote all their daylight hours to their task, in return for which they receive board and lodging and a salary of one or two cents a day. On the large estates head farmers and herdsmen collect dues from their fellows and see that the landlord is supplied

* All photographs not otherwise credited are reproduced through the courtesy of the Peabody Museum, Harvard University.

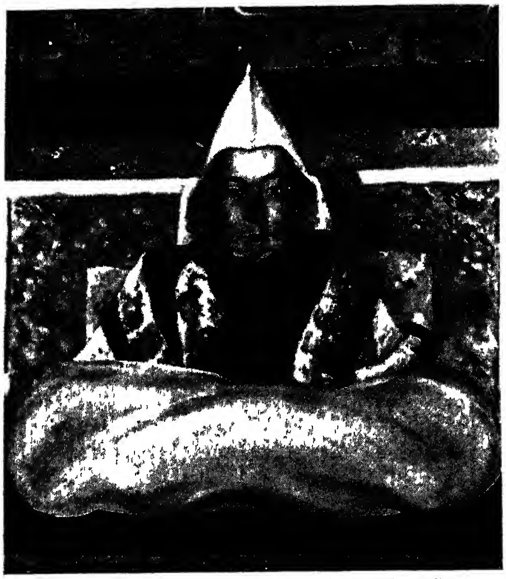
with riding and transport animals when needed.

Tenants and servants thus stand in a position of heavy dependence upon the landed gentry. Social and economic dominance are exercised by the priestly and the noble classes, to whom the subordinated look for the services traditionally associated with their status. Nobles share with priests the higher administrative posts. The former inherit their prerogatives and, while wealth is generally concomitant, it is not necessarily so. Nobles are strictly defined as descendants of (1) an ancestor ennobled for a special service to the country, (2) a family in which a Dalai Lama or a Tashi Lama has taken rebirth, or (3) one of the early monarchs Special titles are occasionally awarded for special services. Sons of landed gentry and nobles usually enter government service, but important lay officials are generally selected from a few ancient and noble families. Only in the monasteries do all men stand a fairly equal chance of achieving marked elevation of social status.

The Supreme Council of Tibet, composed of one priest and three or four laymen, exercises the highest governmental powers under the Dalai Lama or his Regent. There are, below this group, six grades of public officials. The government maintains two lists of officials, one lay and one ecclesiastic, each of about one hundred and seventy-five names. To enter the secular side a boy must first be apprenticed in the Finance Office where he receives training in accounting and the social intricacies of official correspondence. At about twenty he may receive his first public appointment, probably to become a Dzongpön of some little town which he never sees but governs through a deputy. As such, he is responsible for a district, supervising the collection of its revenues and the maintenance of order. After two or three years he may become a judge, deciding both civil and criminal cases and residing in one of the large towns. Subsequent promotions may ensue, the eventual office reached being dependent upon the usual multiple factors, purchase of power being not unknown. Nobles may exercise regulatory powers and inflict punishments upon their tenants and dependents within a rather wide range and in proportion to their distance from Lhasa, though in theory government permission must be granted before drastic action is taken. The aristocracy is scattered over the country, but its greatest concentration and power are found in central Tibet.

The priests act as a check upon the power of the nobles, and many of them are capable and strong-willed self-made men. If a boy is physically weak, if he gives evidence of unusual spiritual powers, or if the family is large and eager for the potential spiritual and material advantage to be gained. a youngster of three or four may be designated for the priesthood. Certain ceremonies mark this decision, after which the child may, if unusual, begin his studies immediately. He will usually remain at home until the age of six or eight. Having studied hard, learning to read and write, and memorizing vast masses of scripture, he may become a "clerical apprentice" by the age of sixteen, and an under-priest at twenty. Having successfully passed an examination, he will reach full priesthood and his functions thereafter will depend upon his special abilities and interests, the sect to which he belongs, and so on. Sects are many; there are perhaps twenty sub-orders and orders, of which about four are truly powerful. Tibetan Buddhism is descended from a much modified form of the faith, namely, Tantrik Buddhism, which reached Tibet from northern India in the eighth century A.D. and led to the "red-hat" orders of the priesthood. The "yellow-hat" orders were a reform group of later establishment and the sub-orders of still later origin. The spirit of the founder of the yellow-hat orders was held to have passed into a child born at about the moment of his death, and the modern Dalai Lama succession was so begun. The title, meaning "The All-embracing Lama, the Holder of the Thunderbolt," was given by the Altan Khan to the third of the line. The title of Dalai Lama is held in turn by each head of the yellow order.

The Dalai Lama exercises greater power and influence than any one else in the country, for he is regarded as the Buddha's Vice-Regent on earth. His position in the regard of the people is, therefore, assured and to him is accorded not only great control over



*Courtesy of Mrs. C. Suydam Cutting*

FIG. 12. INAUGURATING TANCHU, 1940

AT SIX THIS SON OF KUKU NOR SHEPHERDS WAS HAILED AS THE FOURTEENTH REINCARNATION OF THE BUDDHA.

material affairs but the reverence due his exalted incarnation. His spiritual power is nearly equaled, however, by that of the second official in the yellow-hat hierarchy. Dogmatic differences and keen rivalries between the sects and orders exist, but they are based more upon temporal than spiritual factors, and all recognize the two dignitaries above mentioned as the loftiest incarnations of the divinity (Fig. 12).

All the monasteries of the Gelugpa (the order of yellow lamas, as opposed to *all* others, which are regarded as red) are administered by the Dalai Lama through an appointed leader in each district, under whom an appointed "abbot" directs each monastic establishment. This hierarchy holds in general for all the other orders as well, each of which has a head comparable, in intra-order affairs, to the Dalai Lama. Under the abbot, in each monastery, are two classes of dignitaries, the one having charge of its temporal and the other of its spiritual administration. Such monasteries will accept for apprenticeship only superior children of good families. They are well fed and clothed and, by Tibetan standards, highly educated. Thus in the ecclesiastic body there tend to inhere the advantages of efficient organization, discipline, quality, and, lastly, the weight of numbers. Grenard estimates 500,000 for the country.

There are approximately 3,000 monasteries throughout the country, and each is advantageously situated for defense and is well armed (Figs 13–15). Around them are great tracts for agriculture and pasturage, worked by tenants who produce for their ecclesiastical masters not only foodstuffs but also processed articles such as woolen goods, jewelry, and pottery. They are masons, carpenters, smiths, millers, and caravaneers, and are essentially subject to the monastic jurisdiction. The convents also hold accumulated treasures in gold, silver, and precious objects and receive innumerable beneficences, great and small. A bequest to the nearest convent comes from the inheritance of the deceased, the candidate for priesthood brings a dower, and every lama gives the convent part of his personal gains. F. Grenard, in *Tibet and the Tibetans,* remarks:

> For the lama is anything but a worthless asset. He is . . . a parish priest, a fortune-teller, a wizard, a doctor, an apothecary, a painter, a sculptor, a printer, a writer, a reader, a trader or a beggar; he sells little statues, prayer-wheels, books, lucky trinkets, rosaries, indulgences in pills, prayers, formulas, charms and amulets against all possible and impossible misfortunes, remedies, incantations and horoscopes. When a man marries or dies, the lamas come in the greatest possible number to assist him, for cash, when he meets with misfortune, they charge for driving away his bad luck; when he meets with good fortune, they charge for offering up thanks; when nothing happens to him, good or bad, they charge again for preventing things from becoming worse!

And not only for the individual and the family do they perform such functions, but also for the community and the state itself. But not all monks are practitioners. Some take vows of seclusion and may incarcerate themselves for years from the sight of man. Nor are all, as is the rule of the majority, celibate. Great diversity and range exist in the priestly mode of behavior, and the layman, while very fond of criticizing irregular behavior of the monks, is nonetheless respectful of the power they hold.

The complexity and diversity of Tibetan religious belief and practice are overwhelming in scope. One can do no more than attempt to identify within the maze certain

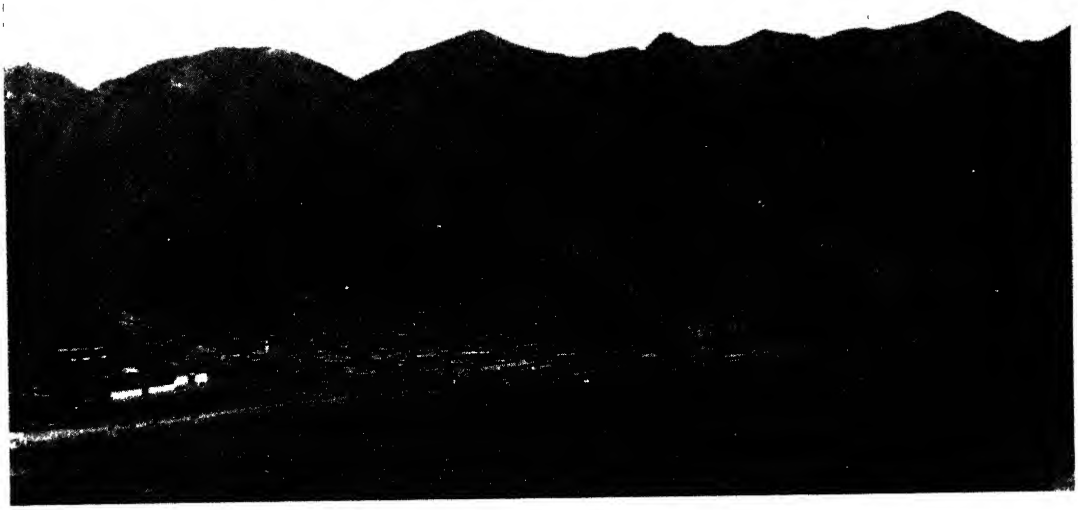


FIG. 13 THE MONASTERY OF LABRANG NEAR TIBET'S NORTHEAST BORDER

familiar avenues of religious expression. At least, it is quite apparent that Tibetan Buddhism is a travesty on Buddhism as originally taught. It preserves the conceptions of Karma and Nirvana, but the fine flights of abstract philosophy which characterized the original dogma are lost. From an abstract and nonpractical (in the material sense) philosophy and a nontheistic religion, Buddhism has become in Tibet a sort of monotheism with an enormous subsidiary pantheon of deified "saints," living incarnations, demons, personal guardians, ghosts, and so on, all of whom can be induced to leave an individual alone or to assist him if he knows the proper mode of approach, conciliation, or appeasement.

In all this there is ample evidence of mere elaboration of primitive Shamanism, the guardian-spirit belief, local "owners" and spirit placings, the association of the name with the soul, and even intermittent ancestor worship. There are indications of the abortive survival of animal sacrifice, the worship of household gods (in particular that of the hearth in association with the family and its continuity), the worship of gods of special function and those of local residence; even the celestial bodies play a part in this accumulation. "Mother Earth" is not omitted; the gods of sky and air, of the elements and of the elemental forces, all are remembered.

With all the multiplication of social, religious, and economic units, classes, and functions, the paternal family remains the basic common unit through which is inherited, to a large degree, status and role, prerogative and occupation, and property both corporeal and incorporeal. Personal genealogy is carefully preserved, and in theory all those united in blood recognize mutual responsibilities of assistance in times of crisis, even to the extent of exacting the price of the blood of a murdered kinsman.

The conjugal pair is usually brought together by the familiar intercessor, after much negotiating between the respective families under traditional conditions of gift exchange and ceremony The bride is ceremonially brought to her father-in-law's house with etiquette sometimes suggestive of mock wife capture and with heavy emphasis upon the exchange of her old household gods for those of her husband's family. Actual wife capture is said to occur among the wilder nomads, while among the more sophisticated

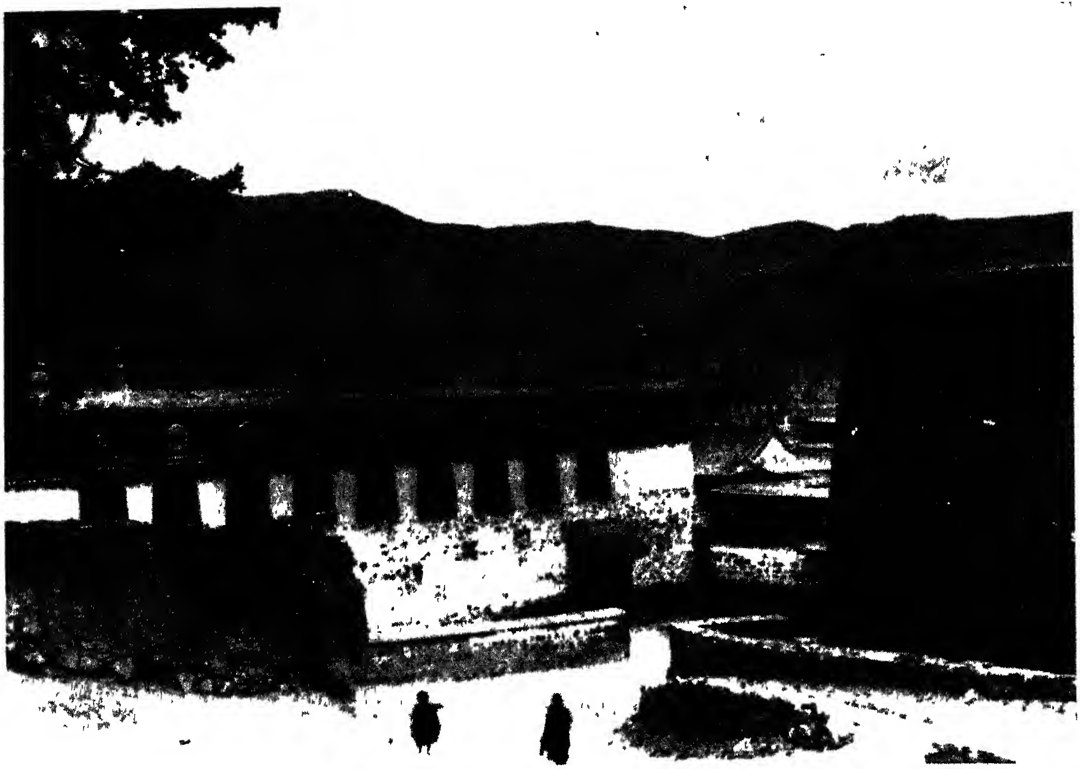


FIG. 14. BUILDINGS OF LABRANG SHOWING ARCHITECTURAL EMBELLISHMENT

townsmen personal preference is given some consideration. Similarity of social and economic status and friendly relations between families appear to be the conditions basic to the arrangement of marriages. Elopement is not unknown, nor is it apparently severely punished. Among the very poor, the establishment of a common residence by mutual consent of the partners and their declaration, with or without witnesses, may constitute marriage.

Polygamy and monogamy are perhaps of almost equal frequency. The practice varies with local custom and the economic conditions of individuals. Among nomads monogamy is said to be of high frequency, coupled with the practice of dividing the patrimony between the sons. Among peasants this practice has practical disadvantages, fields and houses being less susceptible to subdivision than herds and pasturage. Hence, among peasants the frequency of polyandry may be regarded as a possible solution to the problem of keeping property intact, for levirate is the rule. The eldest brother in this case becomes the legal husband and father of the children, and upon his marriage he takes his father's place as head of the family The younger brothers exercise equal conjugal rights, however, and act as "proxies" for the head of the house in carrying on its business. Should the eldest brother die before the majority of his eldest son, leadership passes to the second eldest. The position of younger brothers is that of owning, without having legal rights of administration over, the family property. All, however, are constrained to cooperate for the benefit of the family and the continuance of the line If he desires, the head of the house may take a second and third wife, an arrangement which offers advantages in supplying the younger brothers with wives. Where there is no male issue, the daughter's husband may carry on the family line and take its name.

There is said to be no legal divorce, and the marriage bond is apparently seriously regarded, but in all probability divorce by mutual consent is fairly easy. Barrenness, laziness, or flagrant adultery of the wife are

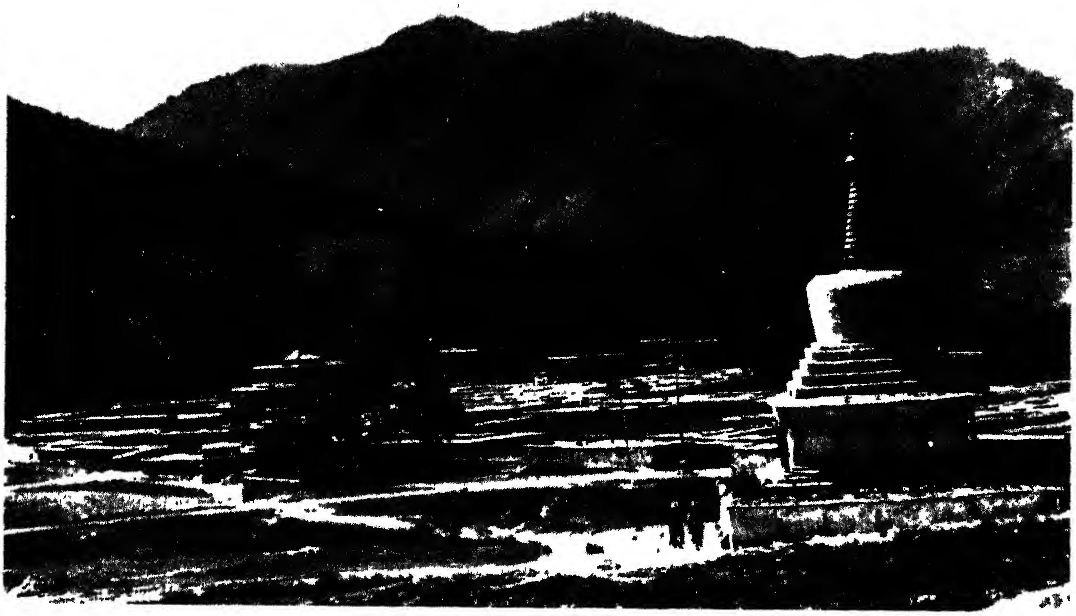


FIG. 15. A VIEW OF LABRANG, SHOWING THE GREAT WHITE STUPA

the chief causes of separation. The last, however, is regarded as serious principally because it threatens the purity of the family line. A close personal friend, an adopted brother, or a distinguished personage will be expected to lay claim to the favors of the lady of the house, since he and his host are regarded as sharing, temporarily at least, in the bond of brotherhood.

Tibetans are said to be moderately prolific, but families are never large, due to the very high rate of infant mortality. There is no female infanticide, children of both sexes being greatly desired. Their education may be completely informal; it may be conducted by a village scholar and his head pupil, or by a private tutor. In any case it is likely to be limited to the "three R's" plus perhaps, among the wealthy, a little biography, history, and law (that is, moral precepts). An educated man in Lhasa is one who can write perfectly the complicated Tibetan script. While nearly all Tibetans can read a little, few can write.

Social diversion in the form of games, drinking and smoking, singing and dancing, centers much about the family life. Tibetans are said to be much in the habit of singing at their work, whether singly or in groups. They employ a number of musical instruments: the Hindu guitar, the Jew's harp, the bamboo or bone flute, and the tambourine. Religious music further involves trumpets small and large, cymbals, conch shells, and drums of many sizes and varieties. Religious dances employ elaborate masks, head-dresses, and costumes. In secular dances men and women may dance together, as may master and servant.

Death is regarded as the release of the soul to a series of adventures which may result in its eventual re-entrance upon the "Wheel of Life." Little by little babies forget their past incarnations, and usually by the time they have learned to talk all memory of the past lives of the soul is forgotten. In rare instances this may not be the case, and so an important incarnation may be identified.

Disposal of the body is by exposure, in water, by burial, or by cremation. The last is reserved for lamas and high officials; the second for the lowest of the social strata—those without family or means. The very highest lamas are embalmed.

Though domestic economy and self-sufficiency within the family prevail in the production of essentials, the occupational specialist is not unknown in Tibet. From the information available it is not always easy to determine whether specialization is full-time; in the majority of cases one would guess that it is not. However, government officials, both lay and ecclesiastic, may be regarded as full-time specialists, as may priests. The occupations of the latter cover a wide range, as has been indicated, but it appears that division of function in the maintenance of the monastery and within the field of religious practice is very high. Professional traders and shopkeepers form a small but important middle class of commercial specialists, while closely allied with them in function are the bankers. The Newars of Nepal are said to be frequently found in the latter role in Tibetan cities. Teachers may be full- or part-time specialists, as are the entertainers who tour the country. In the cities are also to be found Chinese who are professional barbers and great numbers of beggars who, while unproductive in general, have certainly a professional status. Certain ones among them have recognized duties, as the disposal of human and animal corpses, searching for thieves who have fled into the country, and, formerly, the guarding of convicts. They are the scavengers of the city, and their begging status is fully institutionalized and regulated.

Among handicraft and processing specialists are metallurgists, weavers, tailors, shoemakers, builders, potters, and millers. Peasant, herdsman, and caravaneer are specialists to the degree that they produce, within their own sphere of economic activity, a surplus for trade which is relied upon by another group that does not produce such commodity or commodities or does not produce them in quantity to meet its own needs. Hand power, animal power, and water power are utilized, and machine power has been introduced on a limited scale.

Division of labor by sex and by age shows no unique features. Women do, however, play a rather more than usually dominant role in all spheres of activity save religion. Sexual discrimination is there at its height, yet women may become nuns and, in some cases, may be admitted to the monasteries. A woman may assume an important incarnation, in which case she will be accorded great honor and privilege, yet she can never reach the heights of secular power open to the priesthood. Women may manage shops and engage in retail trade generally. To country women fall not only the usual household duties and the care of the young and the infirm, but also carrying burdens, sowing and weeding, gathering fuel, milking, weaving, and the making of butter and cheese. Herding and ploughing are man's work, while irrigating, reaping, threshing, and winnowing are activities in which both sexes engage.

Tibet may be said to stand pre-eminently as an example of the achievement of cultural complexity in the face of environmental adversity. Many of the resources of the country are already being exploited, but when European influence adds techniques and breaks down dogmatic barriers a new avenue of exploitation—that of mineral resources—may be opened. Until that time Tibet may be expected to show little change; to remain a rather anomalous land of feudalism allied with theocracy, of herdsman complementing peasant.

# GEOPHYSICAL MEASUREMENTS IN THE AMERICAN REPUBLICS

By L. O. COLBERT

MANY of the results of the Good Neighbor policy, intended to produce better relations with our sister republics, will have to rely for future value on the impressions made on the minds of men. The cooperative work of the Coast and Geodetic Survey, arranged in these American republics by our Department of State, has resulted in the establishment of permanent monuments, marking the points where precise measurements were made, which will be used for reference in future geophysical observations

These cooperative measurements have included: gravity determinations in Colombia and Peru; the establishment and maintenance of fourteen automatic tide gages in eight countries; magnetic observations in all twenty of the American republics; cooperation in seismological work; arrangements for the exchange of personnel to assure standardized methods of observations; and translation into Spanish of several manuals on these geophysical operations.

*Tidal measurements* One very successful program was the establishment of standard tide stations for the continuous operation of automatic tide gages in eight different countries from Mexico to Chile. An example of the difficulties of the tidal expert is given by the conditions at Panama and the Strait of Magellan. In Panama on the Atlantic side, the range is only one foot, but on the Pacific side the tide ranges from a mean of twelve feet to an extreme of sixteen feet. At the Strait of Magellan the range on the Pacific side is only four feet. On the Atlantic side the average range is thirty feet with a maximum of thirty-nine, one of the greatest of the earth.

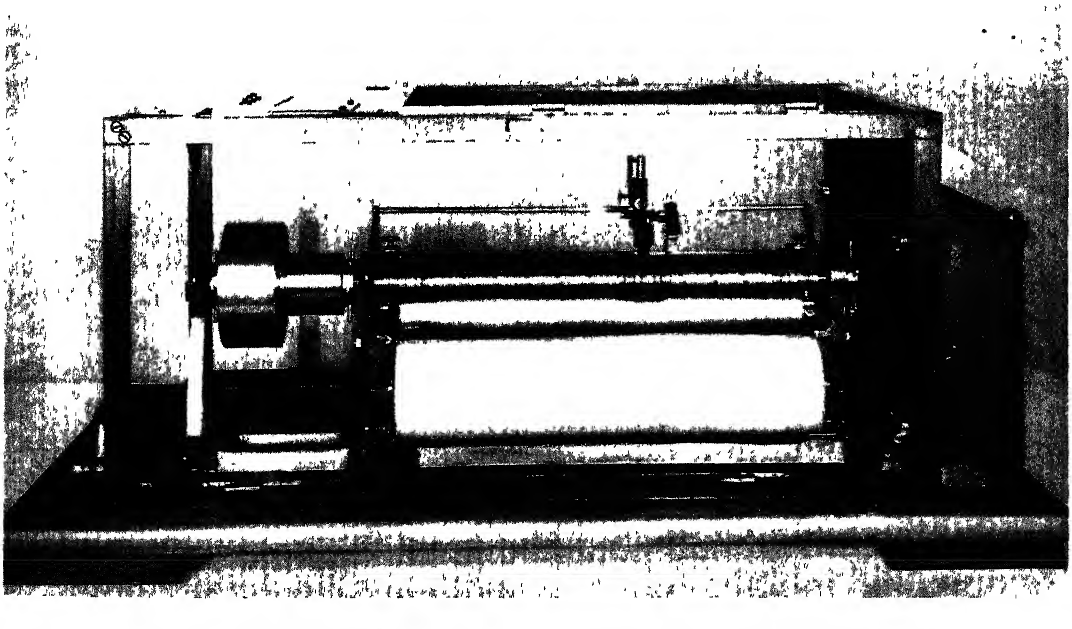


FIG. 1. STANDARD TIDE GAGE, U. S. COAST AND GEODETIC SURVEY

Tide predictions have become commonplace. The average user of the tide tables does not know that back of them is the tide-predicting machine, and behind this not less than one year of continuous tide observations at several ports, followed by mathematical analysis of the results. The Coast and Geodetic Survey has for many years predicted tides for all parts of the earth, but has been handicapped in those portions where observations have been meager.

Because few observations had been made in many parts of the Americas, a number of the American republics welcomed a plan, initiated in 1941, whereby the Coast and Geodetic Survey furnished and installed automatic tide gages at principal seaports and inspected them annually. Each country concerned maintains them in operation and collects the records for analysis. The fourteen stations are distributed as follows: three in Mexico; two in Central America; nine in South America, one of which is in the Strait of Magellan. As a result, the tide tables are now providing daily prediction for the more important ports, especially on the Pacific Coast of South America, and improved tidal data for the whole of that coast.

A tidal station includes an automatic gage, a tide staff, and a number of benchmarks. The automatic gage consists of a recorder (Fig. 1) connected by a flexible wire to a partly submerged copper float. The wire is wound around the pulley on the left of the recorder so that by a suitable mechanism a pencil records the rise and fall of the float with the tide. The recording mechanism is moved along the surface of the clock-driven drum at a uniform rate, so that the record gives a continuous curve from which the height of the tide at any instant may be obtained. The tide staff is simply a board with painted graduations, so placed that it extends above and below the greatest range of the tide. At daily intervals the record on the gage is compared with the readings of the tide staff. This gives the height of the tide with reference to the zero mark of the tide staff.

The next step is to carry a line of levels from the zero of the staff to not less than five reference points on shore, each marked by a bronze disk set in the top of a concrete pier These marked points become individual bench marks of known elevation when continuous observations of the rise and fall of the tide have been analyzed and the various tidal datum planes determined.

Knowledge of the tide is necessary in daily coastal navigation, in connection with waterfront industrial construction, and in harbor improvements. For these uses the maximum, as well as minimum, tidal ranges are needed.

The tidal plane of mean sea level, to which all elevations on land are referred, may be defined as the mean or average height of tide at the point of observation, as derived by analysis of the tide record. It is difficult to arrive at a common plane of mean sea level, as varying meteorological conditions affect the observations at different stations. There may also be slow or rapid changes in elevation, usually associated with major earthquakes, which are especially likely to occur on the shores of the Pacific Ocean The geologist is interested in these from the viewpoint of world-wide changes of mean sea level, especially to learn whether it is the land or sea whose elevation is changing. For these purposes observations over a considerable period of time are required. It is hoped that most of the tidal stations now established on the Pacific Coast from Alaska to Chile will be continued in operation for a number of years.

It is desirable, when possible, to connect all tide stations with precise level lines to determine the difference between the mean sea levels at different coastal points. At the Isthmus of Panama where this has been done, mean sea level was found to be three-quarters of a foot higher on the Pacific side than on the Atlantic. A similar determination at the Strait of Magellan, which would be desirable, cannot yet be made because of lack of sufficient tidal observations at each end.

The west coast of South America suffers from time to time from great seismic sea waves, which sometimes reach the height of eighty feet, causing damage to shipping and to coastal structures. These can now be recorded at those tide gages which are of sufficient distance from the origin for the wave to be within the recording range of the

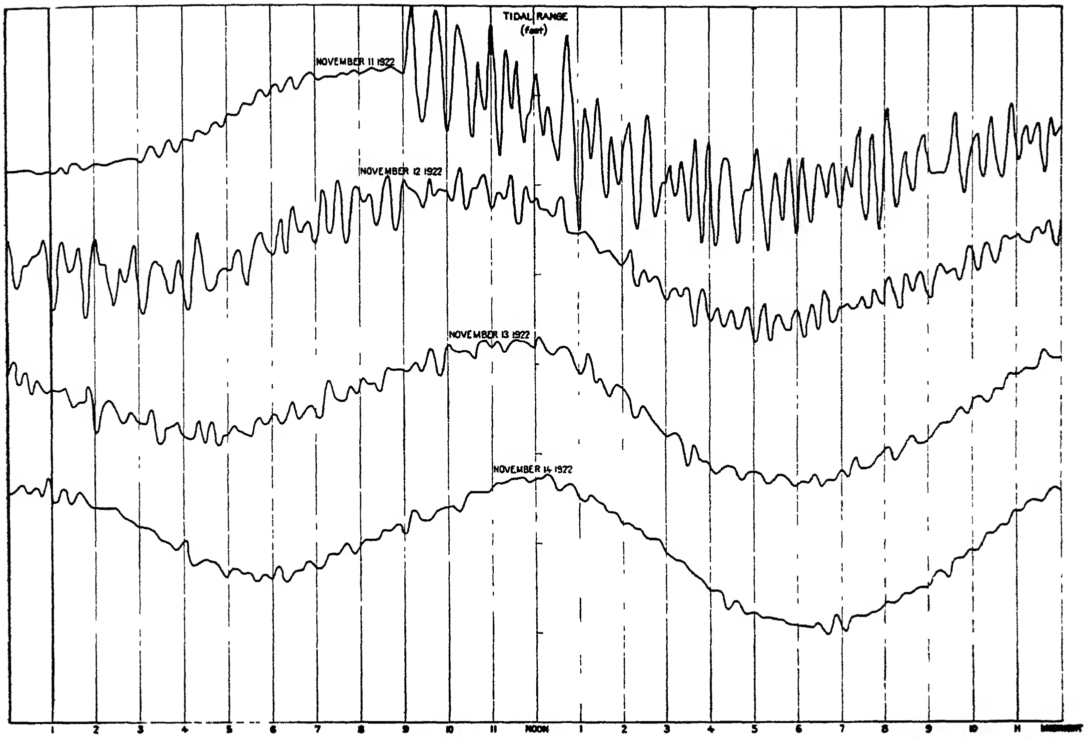



FIG. 2. DESTRUCTIVE TIDAL WAVE IN CHILE RECORDED AT HONOLULU

gage (Fig. 2). No means has yet been found for recording great destructive waves near their place of origin

*Geomagnetism.* The situation regarding magnetic observation in the Americas has been quite different from that of tidal observations. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in order to have needed data for its world-wide studies, inaugurated in 1905 a program of magnetic surveys in all countries which did not have organized surveys of their own Mexico and Argentina were originally included in this program but soon established, and have since maintained, their own magnetic surveys, including the operation of magnetic observatories.

The continuous records from observatories, in addition to serving other useful purposes, furnish the necessary corrections to field observations. Of the observatories used for this purpose, Mexico and Brazil each have one, Argentina three, Peru one (operated by the Carnegie Institution) and Puerto Rico one (Coast and Geodetic Survey). These, however, are too few to indicate the changes in the earth's magnetic field; consequently the Carnegie Institution made repeat observations at selected places at approximately ten-year intervals.

The plan worked satisfactorily through 1932, after which a break in continuity threatened. This was especially serious because of the peculiar magnetic conditions in the area. To understand these a review of the basic facts regarding the earth's magnetism is desirable.

Since a magnetic field is in three dimensions and is difficult to deal with as a whole, it is separated into components usually referred to as magnetic elements. The planes of reference for any point of observation include the true meridian, the magnetic meridian (the vertical plane of the direction taken by a freely suspended magnet), and the plane of the horizon. The elements include: declination, D, the angle between the true and magnetic meridians; inclination or dip, I; and total intensity, F, more usually

broken down into horizontal intensity, H, and vertical intensity, Z The various instruments which serve to measure or to utilize the earth's field usually relate to only one, or at most two, of these elements.

Declination and vertical intensity are in most common use. Anyone who has a magnetic compass can obtain a true direction if he knows the declination at the point of observation. Vertical intensity is used in geophysical exploration for oil and minerals.

The distribution of the field is far from symmetrical, and there are many places where there are marked local departures from uniformity. These are known as magnetic anomalies. They are usually due to the presence of magnetic iron or other ferromagnetic materials associated with igneous rocks and sediments derived from them.

A convenient method of studying magnetic changes with time, or the secular change, is the drawing for a selected period of isopors or lines of equal change of a selected element. In some places the rates of change are large and the isopors form a series of closed curves resembling the isobars of a meteorological depression. These are known as isoporic foci.

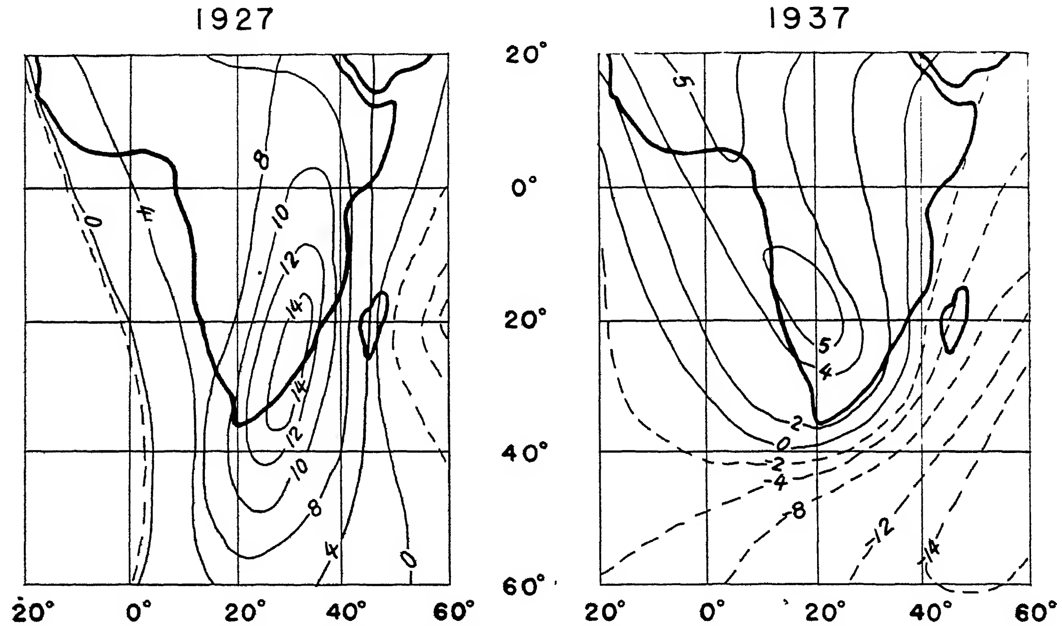



FIG. 3. CHANGES OF ISOPORIC FOCI OF DECLINATION

South America is a region of interesting and unusual magnetic conditions, some of which have an effect far to the north. The magnetic equator, which crosses South America about ten degrees south of the true equator, has been slowly moving southward; and it is important to know whether this trend is continuing, especially as it may be related to movement of the magnetic poles. While daily variation of the magnetic elements is a universal phenomenon, that of horizontal intensity in most of South America is very large, and a daily lunar effect, which elsewhere can be detected only by statistical methods, can be readily separated.

In the recent past there were marked isoporic foci in all the elements in different parts of South America; these foci are subject to change both in position and maximum amount, to disappearance, and to the development of new ones (Fig. 3). The isopors in declination in the United States have been changing in an unusual manner and this may reflect changes to the south. These changes can become known only through continued or repeated observations.

The Coast and Geodetic Survey had demonstrated in its work in Alaska that the field

observing equipment ordinarily weighing 600 lbs. could be reduced to 150 lbs. and thus make transportation by airplane practicable. Silk was substituted for canvas for the observing tent used to protect the instruments from the wind and sun. Three heavy, bulky, padded carrying boxes were reduced to one light, compact case (Fig. 4). To obtain the necessary correct time the airplane or airport radio was used instead of a special radio and battery.

Due to the rapid expansion of airlines in South America, most of the magnetic stations that had to be recovered and reoccupied could be reached by airplane. A cooperative program, therefore, was set up with all the American republics in which the Coast and Geodetic Survey would make the repeat survey which was due after ten years. Observations were made at from one to twenty locations in each of the republics. The two geophysicists were accompanied by one or more scientists of the particular country. In the republics that maintain their own magnetic surveys and operate observatories, the work was confined chiefly to comparison of the Coast and Geodetic Survey field instruments at the observatories.

The observations were made in a tent to protect the instruments from the sun and wind (Fig. 5). The tent fixtures must be nonmagnetic. In fact there also must be no magnetic material on the observer. This applies to all items—eyeglass frames, metal buttons, buckles.

Observations at a field magnetic station usually required two days. The first day's program consisted of testing the station for local magnetic disturbances, making solar observations for latitude, longitude, and true azimuths, and of making a series of magnetic observations including magnetic declination, the horizontal intensity of the earth's magnetic field, and the dip or inclination of the lines of force. The second day was used for repeating the magnetic observations and marking the station.

Magnetic declination was measured by observing the angle between the true north and the direction indicated by a magnet free to swing in a horizontal plane about a vertical axis. The measurement of the earth's horizontal field consisted of a combination of (1) oscillations, which serve to determine the product of the magnetic moment of the oscillating magnet and the horizontal intensity and (2) deflections, from which the ratio of the same two quantities is obtained. Dip, or inclination of the lines of force of the earth's magnetic field, was measured by means of an earth inductor, which is practically a small generator. Its operation is based on the fact that when a closed coil of wire is rotated in a magnetic field an electric current is generated in the coil except when the axis of rotation is parallel to the lines of force of the field. A small astatic galvanometer is used to determine whether or not an electric current is being generated by the earth inductor. The position of the coil is moved until the galvanometer reads zero.

FIG 4 MAGNETIC INSTRUMENTS FOR AIRPLANE TRANSPORTATION TO FIELD STATIONS.

As yet, no satisfactory field instrument has been devised to measure directly the absolute value of vertical intensity of the earth's magnetic field. This component must be computed from the horizontal intensity and the dip; that is, H tan I.

The instruments in the magnetic observatories record the magnetic elements continuously. Thus all variations and fluctuations such as magnetic storms are recorded. Through exchange, the records are studied by scientists of many countries.

The magnetic survey, as far as it has gone,

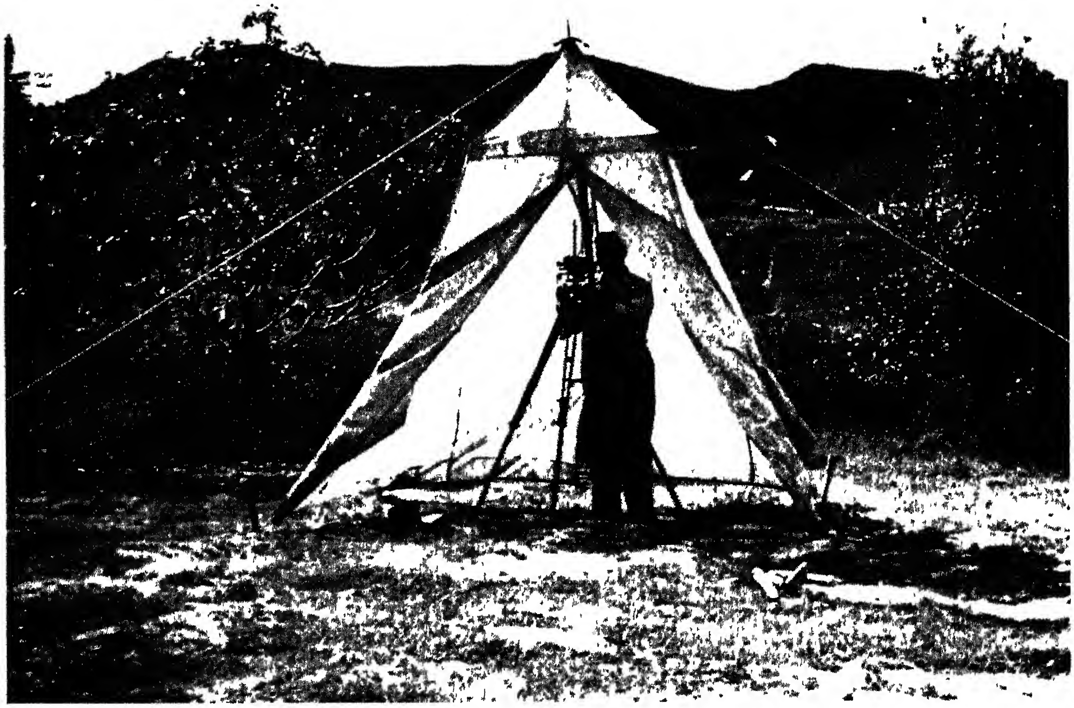


FIG. 5. MAGNETIC OBSERVER IN TENT, SANTA ELENA, VENEZUELA

is up-to-date and the distribution of stations has been improved. The chief need now is for many more observations to map magnetic anomalies.

The earth's magnetism has the unique distinction of being in constant use and yet remaining an unsolved mystery. Its everyday use is in obtaining direction, especially when other methods fail, and in relation to radio communication. Its mystery lies in the failure of all the resources of physics to explain why the earth has a magnetic field and why this field shifts at a variable, unpredictable rate. Continuity of observation, especially of unusual conditions, is an obvious requisite to eventual solution of the mystery.

*Magnetic observations in the vicinity of a new volcano.* A quite unusual and in some respects unique program of magnetic work was carried out in 1943. In February a new volcano, named Paricutin from a village which it destroyed, started its eruption in a cultivated field about 200 miles west of Mexico City. There was no previously known outbreak in the region in historic time, though there was ample evidence of prehistoric activity. The only known similar eruptions of new volcanoes in cultivated land were those of Jorullo, Mexico, in 1759, and of Izalco, El Salvador, in 1770.

Magnetic observations have been made in the region surrounding Santa Maria volcano in Guatemala by the Carnegie Institution of

Washington and the Pan-American Institute of Geography and History, and in the vicinity of several Japanese volcanoes—the most recent being that on Miyake Island in the island group extending southward from central Japan. The reason for such observations is that when the underlying magma becomes fluid, its temperature is well above that at which it loses its magnetism (in the case of magnetite about 750° C.). Accordingly, a magnetic survey may disclose the condition of the underlying magma and may even be a guide to the volcanic activity. As the magma cools, it regains magnetism through induction in the earth's field. The problem is usually complicated by masses of unheated magnetic material.

Under these most unusual circumstances the Coast and Geodetic Survey, with the cooperation of the Mexican Government, made a magnetic survey, chiefly of vertical intensity, in the region surrounding the Paricutin volcano (Figs. 6 and 7). The survey started about three months after the first eruption, and during its progress the volcano was actively building up its cone and extending its lava field. It is too early to appraise the results of the survey except that it appears that there are much smaller magnetic anomalies than for the other volcanoes investigated. This may help to account for the observed wide variation in the degree of magnetization of long inactive volcanic material.

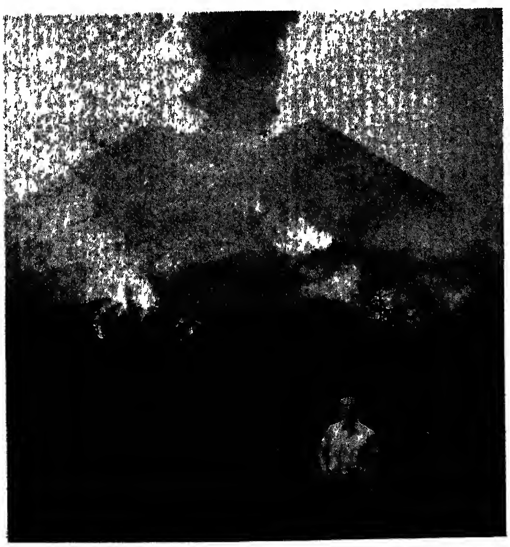


FIG. 6. PARICUTIN VOLCANO
SHOWING LAVA FOUR MONTHS AFTER FIRST ERUPTION.

FIG. 7. MAGNETIC OBSERVATIONS
NEAR ERUPTING PARICUTIN VOLCANO, MEXICO, 1943.

*Gravity measurements.* The first project of the Inter-American cooperation with the Coast and Geodetic Survey was one for the determination of the force of gravity by the use of pendulum gravity apparatus at a number of base stations in Colombia and Peru. Values of the force of gravity of proper distribution over the surface of the earth form an excellent means of determining the shape of the earth. It is well known that while gravity is constant at any point (neglecting geologic changes) it varies from place to place according to latitude, elevation, or the hidden structure below the surface. Quite frequently the differences between the theoretical and actual gravity values (anomalies) from place to place are relatively large after corrections have been applied for latitude and elevation. Such differences are presumed to be caused by absence of isostatic compensation or by buried structures of varied density, includ-

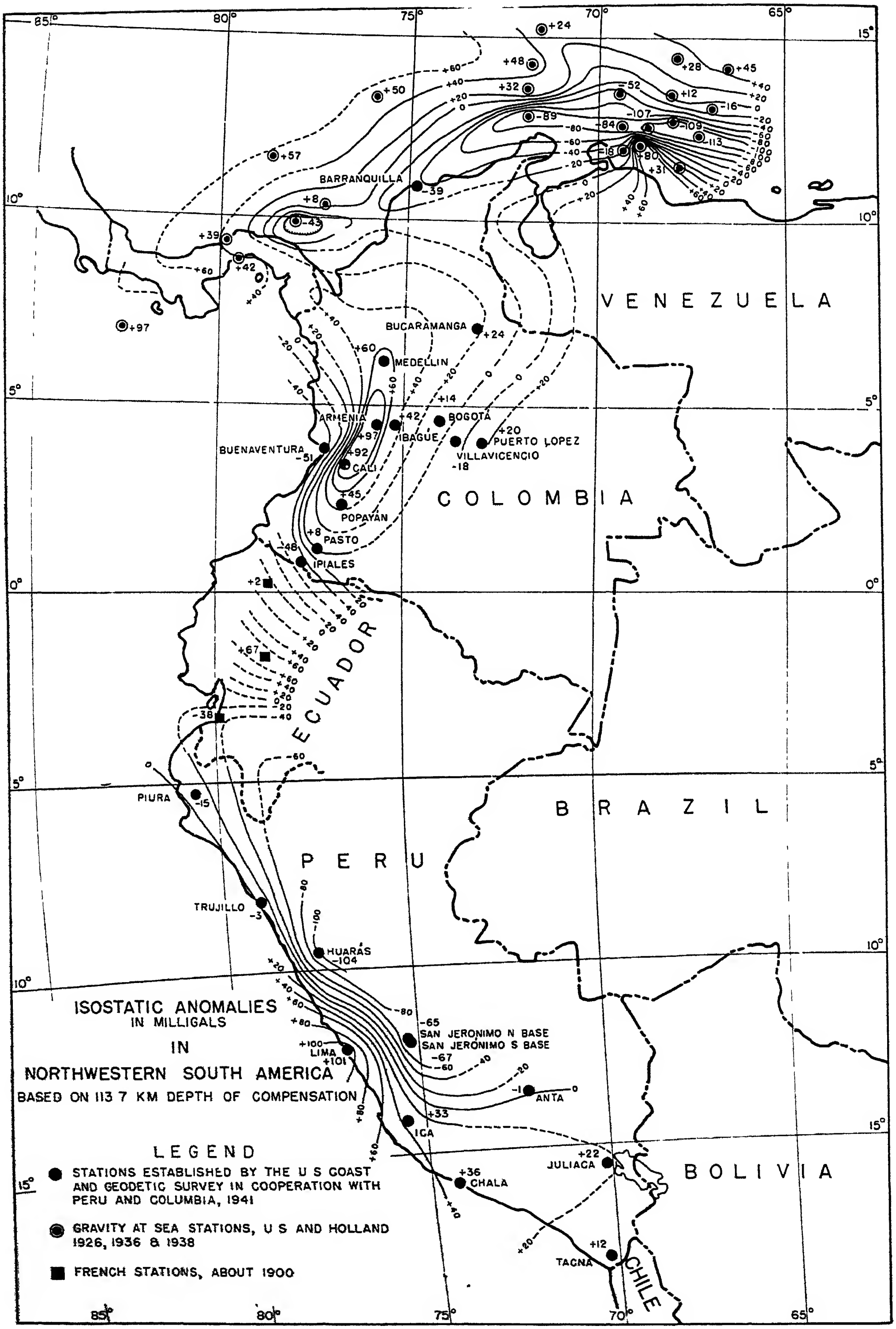



FIG. 8. GRAVITY ANOMALIES ALONG UPPER WESTERN COAST OF SOUTH AMERICA

ing salt domes and other structures associated with petroleum. Accordingly, gravity surveys have been used, for some two decades, alone or along with seismic or other methods, in the search for new oil deposits. The type of instrument now in general use is the gravimeter, which furnishes surprisingly accurate results over restricted areas when the instrument can be frequently tested at pendulum gravity stations.

Because the gravity anomaly may also represent lack of isostatic compensation, importance is attached to the collection of such data in regions known to be subject to intense earthquake activity, such as the western slope of the Andean Cordillera. Already large gravity anomalies have been found through the observations in Colombia and Peru (Fig. 8). The few base stations determined by these recent measurements provide reference points for whatever additional work may be done in the future in those countries for any of the purposes mentioned. Additional observations in these and other countries in South America, particularly those bordering the Pacific coast, would be most enlightening to geophysicists who are studying these matters. Much interest has been taken in the work of the Bureau so far accomplished and in the possible resumption of the work which was suspended because of the war.

The successful accomplishment of these geophysical measurements by the Coast and Geodetic Survey was possible only through effective cooperation of the government in each of the American republics. Furthermore, it is well recognized that there is special need for coordination and maintenance of standards among all the countries on this hemisphere in other scientific work such as triangulation, precise leveling, astronomic observations, and seismology. Many of the countries have been carrying on excellent work in these subjects

There has been nothing one-sided about the benefits received through cooperative effort. The results will be utilized for the mutual advantage of all through a better knowledge of these geophysical features which affect all countries to a greater or less degree.

## REAR ADMIRAL LEO OTIS COLBERT

Admiral Colbert, C.E., Sc.D., is Director of the U. S. Coast and Geodetic Survey, Department of Commerce, Washington, D. C. He was born in Cambridge, Massachusetts, in 1883 and was graduated from Tufts College in 1907 as a civil engineer. He then entered the Coast and Geodetic Survey to which he has devoted his entire professional career. In 1938 he became its Director and in 1939 his Alma Mater recognized his achievements by bestowing upon him the honorary degree of Doctor of Science. Admiral Colbert does not tell us how he became a sailor, but from the start we find him aboard ship; from 1907 to 1910 on wire-drag work on the Atlantic Coast and Alaska, and from 1911 to 1917 as executive officer and later as commanding officer of Survey vessels in the Philippines, on the Pacific Coast, and in Alaska. In September 1917, he was transferred by Executive Order to the Navy and served as Lieutenant and Lieutenant Commander on the U.S.S. Northern Pacific, a troop transport ship. After the war he spent nine years of shore duty in the Washington office of the Survey, followed by three years in Manila as Director of Coast Surveys of the Philippine Islands. Upon his return to the States in 1931 he became commanding officer of the Survey steamer Oceanographer, which was engaged in the use of acoustic methods for making soundings of Georges Bank off the coast of Maine. According to R. A. Daly in *The Floor of the Ocean* this survey resulted in "the first maps to illustrate well the association of canyon, furrow, and ridge. . . ." From 1933 until he became Director, Admiral Colbert was in charge of chart production and correction. His interest in maps also extends to aeronautical charts, for his daughter is a first-class WASP in the Air Transport Command of the Army Air Forces. He is a member of the Mississippi River Commission and trustee, director, or member of several organizations having a bearing on his work. In spite of his preoccupation with war duties Admiral Colbert has taken a great interest in promoting in the American Republics geophysical measurements which are of benefit to all but which are to be accomplished only through cooperation.

# APPLIED GENETICS IN FORESTRY

By G. A. PEARSON

MAN-MADE forests may never attain the grandeur of nature's forests. The reason lies not so much in man's inability to fathom the secrets of nature as in his impatience to reap the reward of his efforts. Nature has taken anywhere from three hundred to five hundred or more years to grow the forest giants which command our admiration and reverence—white pine in the East, ponderosa pine in Arizona (Fig. 1), Douglas-fir in Oregon, or the redwoods in California. Within another half century these biological wonders will cease to exist except where small areas have been preserved for scientific or aesthetic reasons. While commercial forests may for many years continue to harbor remnants of the original stands, they will be made up largely of trees less than one hundred and fifty years old At the present time the clear, even-grained boards which command almost prohibitive prices in lumber markets are sawed from towering veterans of unbelievable age. If we would continue to use this class of timber, we must devise means of growing it in less than half the time nature has taken.

Such, in brief, is the problem which confronts American foresters today. Some would evade the problem by doing without high-grade lumber. They would be content with the small, knotty, and defective boards which now supply much of the lumber trade in the East and South. Others would resort to fabricated material in which small pieces of clear wood are glued together into larger sections of desired form; or they would con-

FIG. 1. A MATURE STAND OF PONDEROSA PINE

IN THE FORT VALLEY EXPERIMENTAL FOREST, ARIZONA. THE TREES ARE ABOUT THREE HUNDRED YEARS OLD AND MANY ARE OVER THIRTY INCHES IN DIAMETER. THEY ARE IN GREAT DEMAND.

FIG. 2. AN OLD CUTTING OF PONDEROSA PINE UNDER PRIVATE CONTROL
LOGGERS LEFT TOO FEW SEED TREES FOR GOOD NATURAL REGENERATION. A NEW VARIETY OF PINE COULD BE INTRODUCED ON THIS LAND IF ONE WERE FOUND ADAPTABLE TO THE SITE.

vert knotty trees into pulp from which a great variety of synthetic wood products can be made. Some investigators believe that, by the introduction of new species from foreign countries or by the development of hybrids, it is possible to produce supertrees which will yield usable timber in a small fraction of the time now required. Still others would rely mainly on selection and cultural practices to bring native species to a high degree of productive efficiency.

In the effort to maintain an adequate supply of wood products in the face of dwindling natural supplies, no reasonable prospect should be overlooked. All the methods here listed deserve attention, but since the first three lie outside the sphere of this discussion, only the last two, involving improved methods of breeding and growing timber, will be discussed.

Plant breeding has revolutionized agriculture and, in somewhat different ways, it can do the same for forestry, which is really a form of agriculture. Tree genetics is being studied systematically at several of the forest experiment stations operated by the United States Forest Service; one of these, the California Forest and Range Experiment Station, has a division of genetics with a field station devoted entirely to the breeding of forest trees.

The thought of hybrid trees combining the desirable qualties of several species or strains appeals to the imagination. Already sufficient progress has been made to indicate astounding possibilities. But the vision of man-made miracle forests replacing extensive areas of natural woodland is not likely to be realized in the near future. To appreciate the obstacles to such a program it is sufficient to enumerate only a few of them.

The long period between germination and seed bearing in forest trees, as compared with most plants, increases manyfold the time required to develop and fix new varieties.

Once a hybrid has been developed in the laboratory and nursery, or a new species introduced from a foreign country, tests under field conditions must run through the greater part of a life cycle in order to determine how the newcomer will react to the many factors of a complex environment.

The introduction of new varieties presupposes artificial propagation, whereas natural regeneration is the framework of the present forestry structure.

On denuded lands requiring reforestation it is possible and practical to introduce new species, hybrids or selected strains after tests have proven them adapted to the conditions of the site (Fig. 2). Because of the tendency toward reversion and to cross-pollination

FIG. 3. PONDEROSA PINE IN THE DRIER PORTIONS OF ITS RANGE
MAINTAINS PURE STANDS BY REPRODUCING ITS OWN KIND EACH GENERATION. IN MORE HUMID SECTIONS, OTHER SPECIES SUCH AS FIRS WOULD TEND TO DOMINATE IN THE SECOND GENERATION.

with remnants of native stock, however, nature could not be relied upon to perpetuate the introduced varieties in succeeding generations. Instead of natural restocking when the crop is harvested, it might be necessary to plant with stock propagated from seed of known pedigree, or from cuttings. But, notwithstanding the difficulties involved, anyone would be rash to assert that this process may not some day become practicable. It seems safe to assume, however, that as long as extensive natural forests remain and prove capable of meeting the requirements placed upon them, they are not likely to be subjected to such drastic treatment as eradication and replacement.

### Guiding Natural Selection

At present the greatest opportunity in forestry lies in the improvement of existing forests rather than in replacing them. Natural forests contain both good and poor types of trees, as measured by both biological and economic standards. The task of the forester is to repress the undesirable and favor the more desirable types.

There are few plant associations in which natural selection is carried on so consistently and so ruthlessly as in a forest. The survivors are certainly the fittest biologically if not economically. Propagation of the qualities which best serve mankind is man's own responsibility. Both heredity and environment figure in the development of the individual tree. Heredity determines potentialities; environment either fosters or inhibits these potentialities. The best of species or strains cannot make the most of their inherent potentialities without suitable physical conditions, nor can the optimum physical complex produce a high-class forest out of inferior species.

The characteristics most sought in forest trees are persistence, vigor, good form, and high quality of the wood.

*Persistence.* Natural forests are, generally speaking, a product of their environ-

ment, plus chance. If undisturbed by man they may be said to represent the producing capacity of what foresters call the site. Composition is determined by the capacity of species, and of strains within species, to tolerate adverse elements of the site and to take advantage of the favorable elements. The trees which maintain their position in the forest through generations must be able to compete with their neighbors for a place in the sun and the soil. They must be able in one way or another to resist or adjust themselves to the ravages of fire, disease, insect and rodent pests; and, finally, they must be capable of regeneration under the conditions encountered.

Ponderosa pine (*Pinus ponderosa*) in the interior and more arid portion of its range is an example of a tree in adjustment to its habitat. It has maintained practically pure stands over vast areas of western United States through generations, and promises to continue so indefinitely (Fig. 3). Douglas-fir (*Pseudotsuga taxifolia*), on the other hand, is a subclimax species, which is usually found in mixture with the true firs of the genus *Abies*. It often starts in pure stand following fires, but after the first generation it gives way to the true firs, which are better able to regenerate under cover.

*Vigor.* Each species has definite limitations as to growth capacity in a given environment; it is found also that within species there exists wide individual variation. Usually, however, the so-called fast-growing species grow rapidly only under conditions favorable to them, and they may fail entirely on poor sites where slow-growing species are able to persist. The popular dream of a


FIG. 4. GOOD AND POOR FORM IN SAW TIMBER

A, ILLUSTRATES THE LONG, CLEAN, COLUMNAR TRUNKS DESIRABLE FOR LUMBER; B, THE MUCH-BRANCHED AND FORKED TYPE THAT IS SPLENDID FOR SHADE BUT VALUELESS FOR LUMBER.

tree which will grow rapidly with little water is likely to remain only a dream. Rapid growth of individual trees does not necessarily signify efficient use of soil, water, and light; it may mean simply that the individual has been able to appropriate at the expense of its neighbors more than a fair share of the elements concerned in growth. It follows that for economic purposes productive capacity should be measured not only in the growth rate of individual trees but also in yield per acre.

Rapid growth is often attained at a sacrifice of quality. Coniferous trees usually produce the best wood, whether for lumber or for pulp, when growing at a slow, or moderate but uniform, rate. Markets for aircraft material and other specialized products commonly specify a maximum width of growth rings in the better grades of lumber. Broadleaf trees, on the other hand, may combine rapid growth with increased strength, toughness, and resilience. Thus, the famed second-growth hickory, much prized for ax handles, is a product of certain fast-growing, young trees.

*Form.* Good form in trees is a relative term, the definition of which depends on the use contemplated. The broad crown and picturesque forking and branching so desirable in a shade tree are characteristics to be avoided in trees grown for lumber. Good form in a timber tree implies a straight, nearly cylindrical trunk, or bole, free of branches to at least half of its height. The opposite characteristics, namely, a short, limby, tapering bole, make for knotty lumber and waste in manufacture (Fig. 4).

The best timber form is attained when trees grow in close formation. Under these conditions competition forces the tree upward, figuratively reaching for sunlight, and encourages "natural pruning" in which the lower branches die and eventually fall to the ground, leaving what foresters call a clean

FIG. 5. PORCUPINE INJURY AND MISTLETOE INFECTION
A, THE FORKED BOLE RESULTED FROM AN ATTACK BY A PORCUPINE WHEN THE TREE WAS YOUNG.
B, A VALUELESS PINE WHOSE BRANCHES HAVE BEEN DISTORTED BY THE MISTLETOE PARASITE.

FIG. 6. MATURE PONDEROSA PINE AFTER THE FIRST CUTTING
THIS CUTTING WAS CAREFULLY DONE BY THE METHOD OF IMPROVEMENT SELECTION. LIGHT CUTTINGS AT TWENTY-YEAR INTERVALS WILL STIMULATE GROWTH IN THE REMAINING TREES.

bole. Open spacing encourages lateral branch growth and persistence of branches almost to the ground. Although species differ in degree of response to these influences, the relationships are universal. Even in fairly dense stands, however, some individuals develop the branchy habit and expand laterally at the expense of their neighbors. Extreme types of this class have for generations been called wolf trees.

Wolf trees may be a product of either heredity or environment. In many instances they are merely the most vigorous growers which, after outstripping their neighbors, have expanded without restraint. In other instances, coarse branching and forking show all indications of being hereditary. A majority of the cases of abnormal branching are traceable to some form of injury. The porcupine, by girdling the main stem of a young tree near the top, arrests height growth and stimulates branch growth. Repeated cutting of terminals by the Abert squirrel in Arizona may bring about similar effects Mistletoe causes branches and even the main stem to assume grotesque forms which may render the tree valueless for lumber (Fig. 5). Snow is a common cause of crooked boles; the young tree is bent over by unequal distribution of the snow load, then when growth is resumed the new terminal shoot rises vertically while the old axis remains in an inclined position.

*Quality.* The wood of every tree has certain qualities which are characteristic of the species to which it belongs. White oak is noted for its strength, hardness, and beauty of figure; white pine for its softness, uniformity of texture, and ease with which it can be worked; red cedar for its rich color, its pleasing odor, and its resistance to decay. Whether a certain quality is desirable or essential depends on the purpose for which the wood is to be used. For instance, beauty of figure and hardness are desirable in a table top, but pattern-making calls for a soft wood free from the irregularities which make

FIG. 7. IMPROVEMENT OF A YOUNG PONDEROSA PINE STAND BY CUTTING
MOST OF THE MATURE TIMBER WAS LOGGED TWENTY YEARS AGO. THE LARGEST REMAINING TREES ARE TOO LIMBY TO MAKE GOOD LUMBER AND ARE DOMINATING BETTER SMALLER TREES.

the pronounced grain in oak and in some pines. Supporting timbers in a house should be strong; but strength is less essential in siding, which in turn calls for workability, paintability, and resistance to the deteriorating influences of weather.

Under present circumstances, the best opportunity for improving quality in woods lies in making the most of desirable characteristics in existing species rather than searching for miracle woods in new varieties or hybrids. In all trees certain characteristics are associated with age, size, and environment. For example, in the so-called durable species usually it is only the heartwood that is durable and heartwood is most fully developed in old trees of large size. Rate of growth and variation in growth rate influence texture, strength, and seasoning qualities. Leaning trees often have an objectionable structural distortion known as compression wood. Clear lumber of any species comes from trees that shed their lower branches early in life; the knotty pine, now gaining favor for interior finish, is obtained from sections of the trunk which have retained live branches, forming a tight knot, as distinguished from the loose knot formed when growth layers are deposited around persistent dead branches.

## Genetics Applied in Commercial Cutting

Strange as it may seem to the layman, logging affords one of the most effective means of improving commercial timber stands. A cutting practice designed especially to favor the best trees in stands of ponderosa pine has been applied in the Fort Valley Experimental Forest in Arizona, under the name, "improvement selection." Trees of undesirable type are marked for cutting while those of the best type are left for growth and regeneration. This selective logging is repeated at intervals of ten to twenty years, always favoring the best elements of the stand by removing the poorest (Figs. 6, 7, 8).

Improvement selection does not overlook immediate economic and industrial aspects. A lumberman compelled to handle only in-

ferior logs would not be able to compete in the lumber market. Trees of such low quality that the sale value of their product will not equal the cost of transporting the logs to the mill and sawing them into lumber or converting them into other useful products are disposed of in the cheapest manner possible, usually by poisoning with a sodium arsenite solution, at a cost of a few cents per tree, or by girdling. Timber management aims to grow a class of product that will return a profit to grower and manufacturer, and at the same time provide maximum utility for the consumer.

In practice, selective cutting designed to improve a forest will proceed along the following lines:

Large, merchantable, mature trees of all classes are cut except as occasional individuals may be needed for regeneration. Merchantable, immature trees are cut if diseased, injured, or of poor form.

Unmerchantable trees whose presence is regarded as harmful to the stand are eliminated at minimum cost by poisoning or by girdling. Especially included are the wolf trees dominating smaller trees of good form and mistletoe-infected or otherwise diseased trees which may infect the younger generation.

Immature trees of good form are left unless they are too close together for satisfactory growth, when the surplus trees are removed in order to improve spacing.

Removal of mature trees is in conformance with the biological law that maturity is followed by decline and that a mature crop of any kind must be harvested if loss and waste are to be avoided. In forest trees, however, maturity is a relative term. Trees which have attained biological maturity may go on growing for hundreds of years if their roots and crowns have room enough to function normally. It is therefore good practice in some species, such as ponderosa pine, to harvest dense, mature stands in a series of cuttings, taking first the largest stems and those which show signs of decline and leav-

FIG. 8. YOUNG PONDEROSA PINE SHOWN IN FIG. 7 AFTER A SECOND CUTTING
TWO OF THE LARGER TREES HAVE BEEN REMOVED, LIBERATING THEIR SMALLER NEIGHBORS WHICH WILL NOW GROW MORE RAPIDLY; THEY ARE BEING PRUNED TO INDUCE CLEAN BOLES.

FIG. 9. A DOUBLE WOLF TREE
KILLED BY POISONING. IT IS WORTHLESS FOR LUMBER, AND IF FELLED WOULD DESTROY MANY SMALL TREES. THIS TREE, BY ITS SHADE AND ROOT ACTIVITY, HAS SUPPRESSED YOUNG TREES WITHIN A SPACE OF FIFTY FEET.

ing others for further growth. Trees of poor form are removed in early cuttings because they occupy space which can be utilized to better advantage by those of normal form. Whether abnormal trees will beget progeny of the same type cannot always be said with certainty. Nevertheless, removal of abnormal types is a precaution in favor of future generations.

Isolated wolf trees and others whose form renders them worthless for lumber can in the younger stages be made to serve a useful purpose temporarily as "nurse" trees. If the crown is not too low, seedlings start underneath its periphery and, under the influence of partial shade, grow into tall, slender, almost branchless poles. Unrestrained, the wolf tree reaches out and strangles these ambitious youngsters, but if the wolf tree dies or declines, they grow into trees of the finest type. Sometimes lightning performs the needed service; man can do it by felling or poisoning the abnormal tree. Poisoning is accomplished by introducing sodium arsenite solution into holes bored in the trunk. Sudden removal by felling exposes the slender poles to snow damage; poisoning leaves the dead tree standing, its massive branches shielding the young poles until they become strong enough to withstand the snow load (Fig. 9).

Mistletoe-infected trees are cut because they are a menace to their neighbors and because sooner or later they themselves will succumb to the parasite. It is common observation, however, that in groups of young trees which have been equally exposed some have escaped infection while others have not. Many foresters believe, and with good logic, that certain strains of a species are resistant to mistletoe. Whether this opinion is right or wrong, future tree generations are undoubtedly safeguarded by removal of individuals which have proved to be susceptible.

FIG. 10. CORRECTION BY PRUNING
EXUBERANT BRANCHING IN VIGOROUS YOUNG DOMINANTS CAN BE CORRECTED BY PRUNING EARLY IN LIFE. THE TREE IN THE FOREGROUND HAS BEEN PRUNED AND LATER ADDITIONAL LOWER BRANCHES WILL BE REMOVED.

Where provision must be made for natural regeneration, trees which bear evidence in the form of cone litter of having borne abundant seed crops in the past are selected as seed trees. Large, mature trees, even though it is probable that they will blow down or be struck by lightning, are left for seed, when needed, if the ground underneath them is blanketed with cones representing several seed years.

Improvement measures are obviously more effective in young than in old stands. Removing a large wolf tree after it has suppressed its smaller neighbors, or removing a mistletoe-bearing tree after infection has spread to neighboring groups of saplings, is much like locking the garage after the tires are stolen. In a well-managed forest there are usually large numbers of seedlings, saplings, and poles, in addition to the relatively large trees left in selective logging. Many individuals in this younger generation may be of undesirable type, and whether a product of heredity or of environment, they should be removed when they interfere with trees of a better type. Some vigorous growers which, though of good form, tend toward excessive branchiness can be improved by pruning off the lower branches in order to form clear boles (Fig. 10). Treatment of young stands by eliminating undesirables and pruning selected crop trees is called stand improvement. In Europe it is considered good practice to bring young forests through the sapling stage in very dense stands, then thinning from time to time by removing the less desirable stems and leaving the better ones. This program provides large numbers to select from and results eventually in a stand of superior trees correctly spaced. Stand improvement is essentially a means of directing and aiding natural selection.

*To summarize,* forest genetics, or tree breeding, may be practiced by two general methods: artificial propagation of hybrids and selective improvement of natural stands by consistently favoring the better types at the expense of those less desirable. The first method can be applied only in artificial regeneration or where treeless areas are forested by planting. Under these conditions the method has great possibilities, but it must necessarily proceed at a slow rate because planting is tedious and expensive. The second method deals with natural forests and therefore has wide and immediate application. Both methods have their place. Neither one has received the attention it deserves in this country, because forestry hitherto has been concerned primarily with the harvesting of native wood crops which could be had for the taking. But the time is not far distant when this Nation's timber supply will be limited to what is grown. Availability, quality, and cost will be determined by the efficiency attained in growing the crop, and in this process genetics is destined to assume increasingly great importance.

# MINING TERMS OF OBSCURE ORIGINS

By EDWARD TAUBE

Inquiry, over a period of years, into the derivations and associated historical details of scientific terms listed in the dictionaries as "obscure," has led to the following discussion of five mining terms.

### Matte

Metallurgists apply the word *matte* to the impure metallic mass formed in the initial stages of the smelting process. In our day it calls to mind the huge quantities of nickel *matte* treated at Sudbury, Ontario; but when it began to make its way into French and English dictionaries, during the nineteenth century, it had already fixed its abode in the Harz Mountains of Germany, in Saxony, and in adjacent mining regions. There, under different spellings and a wide variety of meanings, it had for hundreds of years been familiar to early German miners as well as to the populace at large. After 1171, which marks the discovery of silver in the Saxon hills, Freiberg took on the outstanding position in mining and metallurgy that it held for centuries. Its famous penal code of 1294 decrees the death penalty for anyone found guilty of minting coins with improperly purified silver, with *mathan,* and a milder punishment, the loss of the right hand, if iron is the impurity. In the second half of the sixteenth century Johann Mathesius preached at Joachimstal in the Erzgebirge, a town best known to us because the distant ancestor of our dollar was minted there. This theologian's sermons have appeared in print and constitute valuable source material for the study of early mining methods and mining terms. He speaks of *maute* (heap of ore) time and again.

Among the senses that this noun of ancient lineage and numerous relatives attained throughout Germany and many parts of Europe were "mud," "brass," "peat," "clod," and "bank of earth." The place-names *Motta* and *Cimalmotto* (*Schimmel-mutt,* mold dirt) show that its range extends as far south as the Italian part of Switzerland, and *Mutta* can be seen in Canton Bern, Graubünden, and Solothurn.

Few chemists as yet realize that *matte* is hidden away in the second element of our *bismuth,* a term which has been subjected to much unsatisfactory inquiry. Early references to the metal are most frequent in the works of Georg Bauer (1494–1555), famous as Agricola, the first great expert on mining and metallurgy. In his works, which were written in Latin, he reduced to scientific order the knowledge he had acquired from the miners at Joachimstal in the Erzgebirge, and at Chemnitz in Saxony. This eminent mineralogist often mentions *plumbum cinereum, bisemutum,* and *wismut,* so for instance in the glossaries of *De Re Metallica, Libri XII* (1556), where he records the German equivalents of the Latin terms. The English language now uses *bismuth,* with a *b* replacing an original *w,* a change suffered by a considerable number of words in the mouths and under the pens of Agricola's countrymen. German chemists of our day write *Wismut,* though occasionally also *Bismut, Wiesmat,* and *Wismat.* The term breaks down into the old adjective *wīs* (*weiss,* white) and the noun *mutt* (matte, lump, clod). A touch of white appears in the native metal, and some of its ores and compounds show this coloration to a marked degree; for example, bismuth oxychloride and bismuth subnitrate. Standing alone, the noun could denote the metal too, if the information given in Harrison's *Description of England* (1587) is correct: "A metall more naturall, and the verie same which *Encelius* calleth *Plumbum cinereum,* the Germans, 'wisemute,' 'mithan,' &. 'counterfeie.' "

### Mispickel

Arsenopyrite bears the distorted name *mispickel,* which we find mentioned in English mining literature for the first time in 1683: "All Silver Oars . . . free from Flint, Blent, Cobolt, Mispickel, Glimmer, Wolferan." The work carrying this quotation

was a translation of a German book by Lazarus Erker, chief assayer of the German Empire. The translator, who for many years was deputy governor of the Mines Royal Company, distinguished himself by the publication of several important metallurgical treatises. The spelling applied by Pettus can, of course, be seen in his German source, also in Mathesius's collection of sermons, which, in addition to *mispickel*, has *mieszpieckel, miszpieckel*, and *mispült*, and in Agricola's glossaries, which list *mispickel* and *mispuckel*. Finding a derivation or selecting a correct form from so many variants would truly be a difficult task, if Agricola had not left us a *mistpuckel* too. This immediately brings to mind *Mistbuckel* (manure ridge). Such a name leads to two interesting conclusions. First of all, it proves that early metallurgists had noses sensitive enough to detect the garlic odor of the strong arsenical fumes emitted by arsenopyrite when roasted, and then it draws our attention to the matter-of-fact nature of early mining terms, which in some instances were taken from the barnyard.

### Quartz

Explanations of the word *quartz* have been put forward for several centuries, yet not one has met with universal approval. The preacher Mathesius once again comes to the fore when German attempts to trace the origin are considered. He suggested that *Quarz* is a contraction of *quat* (bad) and *Erz* (ore). Here and there a mineralogist became a disciple of this view. Other Germans thought out their own derivations. One maintained that *Warze* (wart) was the original word, because of the warty appearance of the crystalline elevations. Another connected the term with *Zwerg*, as if a dwarf had by some means or other distorted his name into that of the most common of all solid minerals. French scholars are inclined to regard the Latin *quadratus* as the source, from the angularity of the crystals. Aside from pointing to the German origin, English dictionaries are for the most part satisfied with "doubtful," "etymology unknown," or "of uncertain derivation." One mineralogist is bolder than the lexicographers; he traces the word back to a German ancestor that suggests the sound of clay when kneaded. Such a large number of explanations, diverging so far and all seeking a basis in fact, should warn us against setting up a new interpretation before examining each and every pertinent detail with extreme care.

Scrupulous scrutiny reveals that *Quarz* was originally a variant of *Gries* (gravel). In some German localities it still means gravel. The question of form may be settled satisfactorily. Not only has a great German philologist, Jacob Grimm, expressly pointed to the replacement of a *k* by a *qu*, which permits *quarz* to evolve from the Old High German *crioz* (gravel), but modern German offers a number of words whose variants repeat the *grioz, crioz, quarz* relationship. *Gacken, kacken, quacken,* and *quaquen* (cackle) illustrate this sufficiently well.

The first German example turns up in a poem describing the efforts of a miner to obtain financial assistance from a local farmer. This interesting poem was written in the fourteenth century, either in Saxony or in Bohemia. Things are going exceptionally well at the mine, according to the sales talk:

> First-rate quartz and lustrous copper
> Accompany the gangue.
> It won't be long, if God so will,
> Before good ores we come upon,
> For quartz arranged in such a fashion
> Has never yet led me astray.

Impressed by the unfamiliar terms employed by the miner and misled by the glowing accounts, the farmer from time to time rendered financial aid, only to lose his total investment in the end, for no valuable ores were discovered.

The year 1631 marks the first appearance of the word in an English book, Jorden's work on spas and mineral waters: "Sparr, which the Dutch call Sput or Querts, shoots into points like diamonds." In order to appreciate the full significance of this passage, one must bear in mind that Dutch here means German, aside from noticing that names of minerals were often confused at that period.

### Shaft

"Obscure origin" applies only in part to *shaft*, insofar as some authorities give due recognition to its German derivation, whereas

the larger dictionaries are silent on this point or are inclined to question an importation from the Continent. The famous *Codex Wangianus* contains decrees passed by the bishop of Trent in Tyrol for the purpose of regulating mining activities within his domain. Though written in Latin, it records several words of German nativity, among them *xafetus* in an entry for the year 1208. The monks of Durham, England, constructed a *shaft* for the mining of coal in 1433–34, according to their account books for that year. However, this method of mining may have been known earlier still, because an English monk who wrote in 1366 speaks as if he were acquainted with it. Even so, a sufficient margin of time remains for the loan-word to have crossed the Channel. As a matter of fact, German miners are reported to have been active in England as early as the twelfth century.

The phrase *sink a shaft* may be traced back to the Freiberg legal code of 1294. Section 2 of chapter 37 places all matters pertaining to the sinking of shafts in the hands of a special overseer. In 1583 Ulrich Frosse, a German, took charge of the mines at Perranzabuloe, Cornwall. Besides furnishing the earliest traceable English instance of *sink a shaft*, the letter which he wrote on the 27th of June, 1584, to Carnsewe, one of his backers, offers us an interesting specimen of early English mining literature:

> Wee have at this present gone vp with our newe abdite 10 faddem in the higher Close and Cliered the rouble out of on of the higher shafte aboue, and soncken downe, and so mean to Dryve upward and downe ward, and in sincking thes two shaftes in the higher Clos wee did light with great boules of water betwixt the shafts in the higher old abdite a mongst the rouble, which the shaftes dothe stee, because the shaftes was fuled up with rouble higher then the old abdit is, whereby the water in the old abdite betwixt shaft and shaft is steed, and hath put us to much troble untill hither to, which nowe wee have brought dowen.

## Shode

*Shode* (*shoad*) is weathered ore that has been washed away from an outcropping vein and has been deposited in surface debris at some distance from its point of origin. Here again we have a German mining term.

Repeated entries in state documents show that different rulers encouraged German experts to develop English mining. These came, bringing their special skills and an extensive vocabulary, for Germans were then the exponents of the best mining practice. Hermann de Allemania, Thomas de Almaigne, and Tilman de Cologne are mentioned in the records of the fourteenth century. The high point was reached in the sixteenth century, with Hochstetter digging for copper near Keswick in Cumberland, Schutz erecting improved furnaces with bellows at Beauchief in Derbyshire, and Kranz building a smelter at Larian in Cornwall. *Shode,* which is still prominent in Cornish mining literature, owes its introduction to these experts from Central Europe. First the prospector sought out the heaps of debris in the valleys. Upon locating a *shode* with a favorable mineral content, he tried to guess from the conformity of the ground the direction from which the flood had come that had washed down the deposit. Then he began his search for the metallic veins. While Frosse was digging at Perranzabuloe, Carew was busy compiling a description of Cornwall. His book, which came out in 1602, devotes special attention to tin-mines and the methods employed in finding the ores: "They discover these works, by certain Tynne-stones, lying on the face of the ground, which they term *Shoad,* as shed from the main Load, and made somewhat smooth and round, by the waters washing and wearing."

An interesting record exists of an accusation brought in the middle of the fifteenth century by the prioress at Freiberg against a former mayor of that city. He, so runs the complaint, allowed the moat to deposit its *schute* onto a meadow, thus spoiling its value to the nunnery. Along the course of the Danube we come upon a different spelling of the same word. Below Pressburg the river, whose banks are here quite low, divides into several arms. These form two islands, the *grosse Schütt* (large shode), which is 56 miles long and 31 miles wide, and the *kleine Schütt* (little shode), about one quarter the area of its partner. The shifting sandbanks off the islands are a constant menace to navigation.

# THE NUTRITION FOUNDATION

By CHARLES GLEN KING

THE Nutrition Foundation was organized two years ago by leaders in the food industry as an expression of their confidence in the long-time value of fundamental research and as a sincere acknowledgment of their responsibility for the protection of public health. The entire program is one of public service in a very real sense. Although the plan of organization may be regarded as new in several respects, the underlying principles on which it is based have been well established, we believe, in research experience.

## BACKGROUND

The background of thinking that led to establishing the Foundation involved the following considerations.

A large proportion of the world's exploratory or fundamental research has been, and will probably continue to be, carried out in university research centers. Direct support of specific projects planned by the best men in these centers is probably the most economical way to foster pure research. Such work should be planned and published without regard to the special interests of an individual firm or of any agency that could bring a bias into the picture.

The current trend in American economic affairs has led to serious shrinkage in the income from invested funds. Universities, hospitals, and other endowed institutions will be correspondingly handicapped; hence large-scale corrective measures should be introduced promptly to offset this effect, or the entire social order will suffer. As an illustration of what has happened, President Walter A. Jessup of the Carnegie Corporation recently reported that their income from invested funds had dropped from 4.5 percent in 1932–33 to 2.7 percent in 1942–43.

The trend in tax policies makes it unlikely that individual citizens will find it possible to accumulate large fortunes with which to support or endow universities and other research organizations as they have in the past.

The prospect of increasing government supervision and financing of our educational and research centers—which means, indirectly, increasing political control—presents a picture that calls for careful consideration. Granting that government support of research and education is wholesome and desirable, many citizens feel that these areas of our social order should not be completely dominated by political agencies. The spirit of freedom and initiative is nowhere of greater importance than in the field of scientific research and education. A man's independence in his search for scientific truth is about as fundamental and as sacred as his freedom to develop his own religious life. Therefore a judicious balance of independent support is desirable in these areas, in parallel with state support.

Only a few industries have been able to provide for extensive research programs of a fundamental or exploratory type within their own organizations. Nearly everyone is familiar, of course, with the notable research conducted by the General Electric Company and the Bell Telephone Laboratories, but even such fine developments as these do not, in a broad sense, take the place of our universities. Nevertheless, industrial leaders have developed an increasing appreciation of the contribution that unrestricted fundamental research can make to industrial development and stability, as well as to the community at large.

By joint action the representatives of an industry can accomplish a number of things that would scarcely be possible otherwise. They can give a research program a degree of objectiveness and independence that a single firm could scarcely provide. They can organize broad, long-time research programs involving a number of universities working cooperatively. They can cooperate effectively with the leading research men of the entire country, including Canada, in committees for developing advisory services and for direct cooperation in research. They can foster good will and cooperation within

the industry, and their forthright, public spirited action in supporting the Foundation's program cannot escape public recognition and the development of good will toward the entire industry.

### Organization

The financial plan for the Nutrition Foundation is apparently new in some respects. The entire approach to financing is on the basis of a continuing program, projected five years in advance.

On becoming a member of the Foundation, each firm agrees to make its contribution on a five year basis, and all funds received by the Foundation are scheduled accordingly. As new members come into the Foundation, the program can be enlarged, but the Foundation is continuously assured of at least a minimum budget through the five-year period. Therefore commitments on research projects can be made for as long as five years when necessary—and *in basic research it is often necessary*. Many of the firms have paid their entire commitment during the first or second year. This policy is encouraged for two reasons: advance payments will serve as a cushioning fund against years when current earnings may be low; and by paying the five-year contribution in full, future officers or directorates are not subjected to a binding commitment of their predecessors. Contributions, but not pledges, to the Foundation can be deducted in full against taxation.

Each year the member firms are invited to extend their pledge an additional year, so that the Foundation is not placed in a position of going ahead full steam for a five-year period, with a risk of approaching collapse toward the end of the first five years. There has been a good response to the need for maintaining this projected basis for planning. Nearly all the original members and most of the new members have extended their pledges into the sixth year. The total sum pledged to the Foundation is now $1,428,000. Of this amount, $526,600 has been paid out in research grants.

In selecting the Board of Trustees, which is the governing body, a number of outstanding men were invited to serve as representatives of the public; among these are the Surgeon General of the United States Public Health Service and five university presidents. The public members of the Board are: F. G. Boudreau, Cason J. Callaway, O. C. Carmichael, W. C. Coffey, Karl T. Compton, Charles Wesley Dunn, Father Hugh O'Donnell, C. G. King, Thomas Parran, George A. Sloan, Ray Lyman Wilbur, M. L. Wilson, and Stephen S. Wise.

Recognizing the public service nature of the organization, these men have attended meetings of the Board regularly and have shown an intense interest in what we are doing. Karl T. Compton, President of Massachusetts Institute of Technology, is Chairman of the Board, and George A. Sloan of New York is President.

An important part of the organization is the Food Industries Advisory Committee. These men serve both as an advisory group to the Foundation and as a means of maintaining contact between the Foundation's program and the technical staffs of the member firms. In most cases the members of this committee are Directors of Research or Chief Chemists. The committee does not attempt to serve as a referee body or to pass upon specific grants, but the members play a very important role in building and guiding the organization. On them rests the practical and difficult task of providing the food that the public needs.

Specific direction of the research program is in the hands of the Director and a Scientific Advisory Committee made up of fifteen outstanding research men, most of whom are in university positions. The group was selected primarily upon the basis of accomplishments in pure research, but of course some consideration was given to the need for different points of view, such as clinical or medical nutrition, agriculture, physiology, public health, the armed services, and the broad field of biochemistry, in which most of the fundamental research on nutrition is conducted. The committee meets at least twice each year for group discussions, and is frequently called upon by correspondence. No recommendations are made to the Board of Trustees regarding grants of any kind without first receiving a favorable ballot by this committee. The program is thus kept completely independent of any one person

or firm, and there is a forthright commitment to make the funds as effective as possible in the development of a long-range program of fundamental research and education in the public interest.

All these committeemen serve on a voluntary basis, in the same spirit with which they would accept responsibilities in scientific societies.

Grants are made only to universities or to similar research institutions in the United States and Canada where there are opportunities for outstanding research. To 41 different institutions 87 grants have been made. In many instances there is close cooperation between men in different institutions who are working on special phases of broad problems. The grants range in size from $250 to $12,000 per year, and from one to five years in duration. Projects that develop especially well may be expanded. The largest single increase in 1943 was from $3,600 to $12,000. Many of the grants are in the range of $2,400 to $3,600 because such amounts will provide for well trained post-doctorate research fellows. It is our feeling that funds in support of graduate student and post-doctorate research fellowships, when supervised by men of outstanding attainment, will generally contribute most effectively to the development of pure research.

### Program

For the present, projects that contribute to meeting the war emergency have first preference; for instance, research directed toward improvement of performance in tropical warfare, aviation, recovery from wounds and shock, and protection of civilian health. Specific examples of the Foundation's projects are given below.

*Exploratory or more fundamental studies.* Probably no other project is more characteristic of the Foundation's program than Rose's work on the human protein requirement. It is unusual to have a single project so deserving of recognition in relation to all three phases of our program; namely, war work, public health studies, and purely exploratory research. Giving sharp definition to the human protein requirement, his current studies follow logically upon his classical studies during the past twenty years with albino rats. Closely related work is under way at Johns Hopkins University, Wayne University, and the University of Rochester.

A second group of projects is concerned with basic problems in animal and human physiology. In time these studies will give information concerning the types of functional breakdown that are so prevalent beyond middle age. The projects at Yale University and at Memorial Hospital in New York deal specifically with the role of diet in warding off cancer. Duryee at Columbia University is studying the relation of food intake to the strength of the blood vessels and the related resistance to shock. Projects dealing with liver and kidney function, from a chemical point of view, are being directed by du Vigneaud at Cornell University, Hoagland (Rockefeller Institute) and Ralli at New York University, Luck at Stanford University, and Hodge at the University of Rochester.

In normal experience, more than half of the human body's total energy is derived from the burning of carbohydrates, or sugars. In addition to providing a source of energy, such metabolism is basic to our whole body economy, including muscles and the specialized brain and liver cells. A better knowledge of such changes is certain to improve medical practice, as in dealing with diabetes, and it would be extremely helpful in understanding military, aviation, and industrial fatigue. Grants in support of such studies have been made to Hastings and Westerfeld at Harvard University, to Stotz at Cornell University, and to Clarke and Stetten at Columbia University. Earlier basic studies of this nature now contribute to better aviation performance as well as to medical practice.

Other grants in support of exploratory types of research deal with such problems as: the isolation of new vitamins; the biological function of mineral elements, such as iron, copper, and calcium; the development of accurate methods for measuring the nutritive value of proteins and vitamins; the isolation of the catalysts that control combustion reactions in the body; and the search for a reliable yardstick by which to measure the food intake—in other words to find the optimum levels of all nutrients that are essential.

*Projects related closely to public health.* The medical profession is beginning to feel confident that clinical or human nutrition has enough scientific standing to be recognized as a field for professional specialization. Nearly every alert school of medicine and school of public health is now scouting for properly trained young physicians to build a teaching and research division of nutrition.

A grant of $7,500 per year for three years was made last summer to aid Vanderbilt University in building up a strong nutrition center. The project is supported jointly by the Rockefeller Foundation, the State Department of Public Health, and the Nutrition Foundation, and it involves cooperation between the medical school and the public health services. Harvard University receives $5,000 per year to assist in the training of young physicians in the science of nutrition.

The nation is gradually awakening to the seriousness of our ignorance regarding tooth decay. It was shocking to find that among the first two million men called to military service, dental defects were responsible for one-fifth of all the rejections. Hence Elvehjem at the University of Wisconsin was given assistance to undertake a carefully planned study of the relation of nutrition to dental caries. For the time being he is placing special emphasis upon studies with monkeys, because they are the only animals similar to man both in nutritive requirements and in the development of their teeth. Projects at the University of California, Yale University, and the University of Rochester supplement the work of Elvehjem's laboratory.

In Detroit Hoobler is studying the composition of mother's milk as a basis for improving the diet of mothers and infants. At Cornell University Maynard has organized a parallel study of the composition of cow's milk. The combined studies will establish a chemical basis for modifying cow's milk when mother's milk is not available. Both groups are collaborating with Longenecker of Pittsburgh in making a detailed study of the fats in milk.

Warkany at the University of Cincinnati has found interesting leads regarding the effect of the mother's diet upon malformations in the offspring. Such deformities as cleft palate, poorly formed jaws and spines, and missing toes are induced in experimental animals by poor diets; and, more important, they are prevented in large degree by good diets. There is genuine interest in the possibility that these findings will explain some of the deformities in human offspring.

Cerecedo at Fordham University is studying the relation of good nutrition to the capacity for lactation in experimental animals. This work in New York and the foregoing studies in Cincinnati, Ithaca, and Pittsburgh, all add elements of strength to the observations on maternal and infant nutrition at Detroit.

At McGill University, Struthers and Hunter are undertaking a study of the protective role of good nutrition against rheumatic fever in children. Coburn, whom the Foundation is helping at Columbia University, has been getting very encouraging results in preventing the recurrence of rheumatic fever in children by means of good food. It should make a fine contribution to better child health if Coburn's work can be confirmed and extended in the Canadian laboratories.

Illustrative data (Table 1) taken from a recent paper by Burke, Beal, Kirkwood, and Stuart of Harvard Medical School, point

TABLE 1

RELATION OF HOME FOOD PRACTICES TO MATERNAL AND INFANT HEALTH, BASED UPON 216 CASES, OVER A PERIOD OF TWELVE YEARS[1]

| Mother's diet | Infants classed as "superior" | Infants classed as "poorest" | Incidence of pre-eclampsia among mothers |
|---|---|---|---|
| | *Percent* | *Percent* | *Percent* |
| Good or excellent[2] | 56 | 3 | 0 |
| Fair .. .... | 35 | 18 | 8 |
| Poor or very poor[3] . | 9 | 79 | 44 |

[1] These studies were conducted before the Nutrition Foundation was organized.

[2] Approximately the levels recommended by the Food and Nutrition Board of the National Research Council, 1943.

[3] Approximately 40 to 60 percent of the Recommended Dietary Allowances of the National Research Council.

convincingly toward the contribution to public health that good nutrition can make in America.

*Publications.* The only publication supported by the Foundation is a new journal, *Nutrition Reviews.* Its purpose is to make available to physicians, teachers, public health workers, food technologists, dieticians, and others who are professionally responsible to the public, a critical, unbiased review of the world's current literature in the science of nutrition. The editorial staff is selected from experienced, independent research people. Paid subscriptions to the journal have grown steadily, without any promotion or advertising, at the rate of over fifty new subscriptions per week, the total exceeding 3,500 within the first year. A Portuguese edition is now published in Brazil, under the supervision of Dr. J. De Castro.

A byproduct of membership in the Foundation, in a number of cases at least, has been to increase the support of research by member companies within their own organizations. At each meeting and during intervening discussions, I believe that the trustees of the Foundation see more clearly that research should have both immediate, or applied, and exploratory aspects, and they are increasingly sympathetic toward long-time objectives in nutrition research.

No doubt each industry will approach its support of research from slightly different angles, but thus far no serious flaws have shown up in the pattern of organization of the Foundation. Within the past few months, the Sugar Research Foundation and the Refrigeration Research Foundation have been established along similar lines, but with greater emphasis on applied research. Several other industries have comparable plans under consideration.

Each grant made by the Nutrition Foundation is an investment in better public health, more intensive training of young people in research, and a higher level of public service on the part of the food industry.

# THE INCENTIVES OF SCIENCE

By C. JUDSON HERRICK

THE annals of science, of art, of industry, and of philanthropy record numberless instances of persons who have sacrificed their own profit and comfort, and even family welfare, to an ambition which to the more practically minded may seem visionary, perhaps even fanatical. When Palissy, the potter, burned the family bedstead in his furnace to salvage an experimental enamel and when Walter Reed's heroic band voluntarily inoculated themselves with yellow fever to test a theory, these men were not motivated by craving for fame or hope of royalties that might accrue from their discoveries. They wanted to know something, and no price was too high to pay for this knowledge.

This craving for knowledge is the basic motivation of all great scientific work and, accordingly, modern science has elaborated a code of procedure designed to check the accuracy of our knowledge in every practicable way. The accumulation of factual data is made as complete and exact as possible, and the validity of every fact is checked against its congruence with all other relevant experience. This body of verifiable facts bulks so large as the foundation of all science that science is often defined as factual knowledge systematically organized, and nothing else.

This conventional code, like every other formal Credo, misses the crucial issue. It substitutes static intellectual belief for the vital process of productive activity. Science is not a dead structure erected upon this or any other foundation. Factual knowledge is only the substrate from which living science grows, and when growth stops science withers and what remains is dogma. No single fact or principle of science may be accepted as absolute truth. Our "laws of nature" are all subject to revision in the light of new evidence. A dogma held to be final may obstruct progress for centuries, as happened in the case of phlogiston and the indivisible atom.

Living science does not grow by accretion of facts, as a glacier is enlarged by precipitation; it grows by intussusception like every other organism. When new facts are fitted into the growing structure, the pattern of the structure itself may be changed as radically as is that of the tadpole when it becomes a frog. This happened, for instance, at the time of Copernicus, and in our own day quantum mechanics is activating a similar metamorphosis.

Traditional dogma is as treacherous in science as in philosophy and religion. Our slogan is: what is the evidence? The printer's rule, "Follow copy if it goes out the window," may be recast—"Follow the evidence come hell or high water." But the meaning of a fact, say the spectrum of a star, may be quite different now from what it was before Einstein. Facts have meaning, not in themselves, but only for people, and when people change as their experience is enlarged, the principles of science reflect this change. For science is made by people. It is a growing thing because the people who create it are growing, and science grows by its own internal agencies in just the same way. A search for eternal verities by the scientific method is a vain quest. At present the principles of relativity dominate the picture.

The implications of this way of looking at science involve drastic revision of some of our most cherished dogmas. If science is motivated and quickened by human interest and if its pattern is designed in terms of ever widening human experience, then to dehumanize it is to kill it.

The devotees of science—I mean so-called pure science—who live perhaps with their heads in the clouds, are the pilots of our destiny; but they are not flying blindly. The course must be charted with reference to known and stable landmarks on the ground, if not by eye, then in some other way, perhaps by faith. But this faith is not blind. It is guided by rational interpretation of previous experience with the realities of things as they are. Without these contacts they lose their way and perhaps crash in disaster. Scientific truth is appraised in

terms of its meaning for people who live on the ground and who must adjust their lives to the terrain where they make their livings. Facts have no meaning for us except as means to an end, the objective being survival and getting as much satisfaction out of it as possible.

It follows from this that we must give up the notion that science is a body of objective facts and impersonal abstractions. It is intensely personal, for there is a person at the focal point of every great discovery and the discovery itself is a reflection of this personality. It is significant only to other persons and what that significance is depends in turn upon their own personal experience and qualifications. It has meaning for any one only in terms of his own pattern of life. Some of the most futile people I have ever known are very learned men, stored with vast accumulations of knowledge, none of which is of any significance for them or anybody else because they cannot articulate it with the pulse of life as it is actually lived.

The achievements of science and its technological applications have enormously increased the production of goods, with corresponding enlargement of wealth and opportunity for better standards of living. But at what cost? Clever mechanical devices perform our menial tasks and thus free our hands for more satisfying activities. But what use are we making of this gift of leisure? Do these gadgets which save time and almost annihilate space really yield those values which make life more satisfying? That depends on the quality of the people who use them.

There are many who claim that the encroachments of science resemble cancerous growths that threaten all human values and virtues. Bertrand Russell has said, "The sphere of values lies outside science," and when science "takes out of life the moments to which life owes its value, science will not deserve admiration, however cleverly and however elaborately it may lead men along the road to despair."

Science has been accused of many crimes of which it is quite innocent, but here is a place where past failures are discreditable. Our failure to readjust the objectives for which we work and the methods of operation so as better to serve the major human issues now before us in the management of our personal affairs and social relations has tragic results. The responsibility for this failure to meet urgent opportunities and obligations lies with men of science themselves. Here I speak with deep conviction and, as a contrite sinner, with great humility. We men of science have failed to appraise our own values intelligently and to instill them into our pupils as skillfully as we might, had we tried harder to do it. Too often we have stubbornly refused to admit the truth recently voiced by a sociologist, that "values represent no special or unique problem in the social sciences" and that science—all science—can practically deal with human values and does so, whether we acknowledge it or not.

Bertrand Russell truly says that the tradition of our cult is that the sphere of values lies outside science. If this tradition must be complacently accepted, I should be inclined to agree with him that such a science "is incompatible with the pursuit of truth, with love, with art, with spontaneous delight, with every social ideal. . . ." But this is a hideous caricature of actual science. It is false to the history of science, to present practice, and to our hopes for the future. When Ogden and Richards say that "scientific meaning is a pure pointing to things without attitude or indication of behavior," this is to throw into the discard the vital germ of untrammeled imaginative thinking, leaving in our hands only the dead husk that can be so easily weighed, measured, classified, and then stowed away in the warehouse as a museum specimen or a printed document.

If science had no interest in human values, there would be no science at all. Nobody would devote his life to the investigation of fundamental problems of no obvious immediate practical significance if he did not feel that he was getting something worth-while. The expenditure of long hours of gruelling toil must yield some return which is considered of sufficient worth to justify the cost. These values cannot be ignored by that science which is motivated by them. They are not decorative accessories of scientific work; they are intrinsic components of science as

it is actually practiced. This is true in all fields of science, and when we look at the social sciences we find these human interests and values at the core of every problem. Here the past failures arise from failure to recognize this obvious fact. We can never hope to find the answers to the questions of most vital concern to us by ever so clever an application of a scientific method which excludes the essential features of the problem from its formulation.

Values belong in science because they belong in nature, not only in human nature, but in all animate nature. Some of our most expert philosophers describe a value as a polarized relationship between a living individual and the object of interest, craving, or need, from which it follows that "satisfaction is the touchstone of value" (Santayana). Now, all animals have needs and all animal behavior, including human conduct, is an expression of the "satisfaction of the motivating conditions" (H. A. Carr). This satisfaction is a value, whether it is achieved unconsciously, as in reflex, or by intelligent purpose, as in making a dinner or painting a picture. There is, then, in nature a hierarchy of values, from elementary survival value common to all living creatures up to human desires, hopes, and aspirations. These values motivate conduct; they inhere in all vital activity as such. Let us then leave our values where we find them, in the natural world, and then in terms of actual experience with them try to sort them out and to appraise their relative worth in adjustment to life's situations as they arise.

The advancement of science will go faster and further if we attend to these intrinsic values sympathetically and constructively. This may require more of insight and courage than some timid laborers can command, but these "hodmen of science" are not the architects of our destiny. It is, I am sure, a practicable enterprise to write a natural history of values along the lines suggested, and the preparation of such an essay would be good sport for a qualified naturalist.

This view of the place of value in science I can document from my own personal experience in scientific investigation. As a biologist I have consumed a considerable quantity of good white paper recording my observations and reflections upon them. Why? Well, for one thing, because I like to do it and get satisfaction from finding out things about my own body and how it works. And also because I think that this knowledge is good for me and for all other people. If I did not feel this way about my work, I would not do it, but would earn my living in some other way. So I am looking here at the life of science and the aims and methods of science from the inside of the workshop, from the standpoint of the man who is doing the job.

Toward sundown as I look back over the day's work it is natural for me to ask, "What is the good of it? Does my business pay? If so, in what coin?" I am speaking now, not of my job as a teacher, for that business I am sure is profitable. Good teaching perhaps yields larger returns in public welfare and personal satisfaction than any other job on earth. I believe in it and I like it. But a large part of my time and energy has been devoted to scientific investigation, and for this also I have been well paid. After more than fifty years of intense preoccupation with these studies, none of which have any immediate practical applications, it is fitting to inquire whether the investment has yielded adequate returns.

In science we are searching for the truth, searching with singleness of purpose and with all our might. This search costs time, effort, and money. Now we are solemnly assured by eminent authorities that in this search human interests and values have no place. If found at all, they are by-products or a contamination. The ideal of pure science which has been set before us is so refined—"truth for truth's sake"—that the values are swept away in the flux as dross to be thrown out or turned over to technology. Out of this slag applied science may make a fortune, in cement or something, and pure science has left—a truth. And science is content, perfectly satisfied.

But something is wrong here. Satisfaction is a value, so our philosophers say. Maybe the truth is valuable; it is certain that it often gets us out of tight places. Puddin' head Wilson's advice is safe, "When in doubt tell the truth." So when science

in her disdain of values achieves a truth and finds satisfaction, she automatically creates value in spite of herself.

These values of pure science are so inextricably intertwined with those of applied science that the old distinction between these two fields has faded out of the picture. We are reminded of Karl T. Compton's acute comment that science provides "a way of securing a more abundant life which does not simply consist in taking away from some one else. Science really creates wealth and opportunity where they did not exist before . . . a cooperative creative effort in which everyone is the gainer, and no one the loser."

When these teachers of philosophy and scientific method assure us that science knows no values, just what do they mean? Well, for one thing they would impress upon us that the first task of science is the orderly arrangement of the facts of experience into a coherent system of knowledge. The ideal held before us here is an impersonal and unprejudiced judgment in the separation of the true from the false and the systematic arrangement of the facts discovered, stated so far as possible in quantitative form. From the uniformities thus revealed the so-called laws of nature are formulated, not as personal opinions, but as verifiable objective descriptions of natural things and events. In this first task the most treacherous of all subversive enemies of sound scientific progress is the bias arising from unrecognized personal attitudes, interests, and preconceptions. There is a "personal equation" here which never can be completely eliminated. The best we can do is to try to recognize it and make due allowance for it with all appropriate checks and counterchecks.

So far we are on safe ground. There is general agreement that this is sound scientific method. According to the generally accepted code this is all there is of science; its task is finished. This I deny and maintain that this first step has merely laid a firm foundation for further building. Science is unfinished and indeed futile until the superstructure is added. We want to know what these facts mean, not to some detached omniscience, but in terms of actual human interests and problems of adjustment.

Attention has already been called to the joker concealed among the building stones of the factual foundation, for this knowledge of facts and principles so laboriously acquired is all derived from human experience; no other kind of evidence is admissible according to the code. And experience is always experienced by somebody with human interests, limitations, and imperfections. The easy way out of the difficulty is to ignore the troublesome personal factors, but actually this cannot be done, and we cannot afford to try to do it, for, as already pointed out, the interest and attitude of the investigator are key factors without which an inquiry would not be made in the first place and the result would be fruitless in the end.

No, this is not the way out. It is as important in scientific research as in teaching that the facts have meanings. Until these meanings are revealed, either by the discoverer of the facts himself or by some successor, the accumulated knowledge is a token of potential value like gold dollars stored in a government vault. So long as it remains in the vault it has no value except as reserve. To be productive it must be put in circulation. So knowledge which does not touch human life would not be worth anything. The saving feature of this situation is that all knowledge does touch life. Sooner or later it will be fitted into place as part of the armamentarium of successful human adjustment, so that our stores of even apparently useless knowledge comprise a valuable reserve upon which drafts are constantly drawn in the promotion of new enterprises. All advance in pure science and most of the inventive marvels of applied science are directly dependent upon these stores of accumulated knowledge, much of which was acquired with no expectation of immediate practical application. The investment is sound because the token represents real value as soon as it is put into circulation.

The conclusion is that the natural sciences are afflicted with the same malady which has recently been diagnosed in the humanities. It is not a paralysis which inhibits activity, but a defect of vision, of that inner vision that we call insight, which confuses the vital issues. It is not like a cataract that obscures

all vision; it is a mental squint complicated by myopia, scotoma, and astigmatism, resulting in distortion of everything in the field of view. This has a shocking sound and it really is bad because, though we may be going very fast, we do not arrive anywhere and we stop before the job is finished.

The ultimate aims of humanistc and scientific activity are the same—to enrich life and enhance its satisfactions—but as we take our devious ways, blazing trails through the untrod wilderness of unpredictable and confusing new experience, attention is distracted by interesting detail on the way and the primary objective is lost to view.

We want something better than what we have now, and we want to be better than we are now. But what is better? There is only one way to find the satisfying answer. Not by wishful thinking, not by disputation about transcendental mysteries of absolute truth, right, and perfection, but by actual experience with the various things that we prize and work for, measuring the satisfaction won by the price we have to pay. If content with shoddy values, life is shabby. It does not follow that the cheap values are most easily won, for a gaudy bauble may cost more than priceless treasure and our choicest satisfactions are free as air.

Of course pure air is not free if my neighbor fouls it with noxious fumes and it may cost me an expensive lawsuit to be rid of the nuisance. So every interest that we have is directly or indirectly tied into our social relations. In this soil we find the roots of altruism whose flower gives us our choicest satisfactions. As has often been pointed out, our moral values top the list even when viewed from the scientific standpoint, for social opportunities and obligations form the cement which holds society together. Without intelligent adjustment here civilization perishes and we perish with it. In the long view moral rectitude has actual survival value. This lesson, which all of us are slow to learn, is now being taught to some criminal aggressors the hard way.

Our standards of value, of what we prize and work for, have actually been built up in terms of human experience. The analysis of this experience in the light of what we want and what is available for its acquisition involves a judicious selection from among all the desirables before us. This judicial appraisal of our values is essentially a scientific problem. Science will not fail us here if we have the insight and the courage to follow whithersoever it leads, but it is powerless to help us in this quest unless released from those fetters of traditional dogma which hitherto have crippled its efficiency in this domain of major human interest. Only when science is keenly alert to its own values can it contribute anything toward judicious pursuit of other values. A science which renounces its own intrinsic values is blind and dumb in that domain where keen discrimination and courageous speech are most needed.

The cardinal thing about science is not its facts or its principles; it is its method of enlarging experience and solving problems in terms of that experience. Science is not an inert body of knowledge; it is a way of life. The life of science must not be confined in the ivory towers of academic seclusion nor within the soot-begrimed walls of industry. It must infiltrate, quicken, and guide every human enterprise. This requires trained and disciplined leadership by men of science who are willing and eager to accept, not only the opportunities given them by society, but also the social obligations which acceptance of these gifts implies.

The life of science is not all of life. The rare idealism which motivates production in research, in literary and artistic expression, and in philosophical inquiry is not a scientific product, a figment of imagination, or a religious dogma. It is the highest manifestation of life, of all of life and the fullness thereof. The task of science here is by honest inquiry in all humility to seek for guidance in the search for what is true, what is good for us, and what will make life richer and more satisfying.

# SCIENCE ON THE MARCH

## THE CAUSATION OF DISEASE

THE evolution of etiologic thought, like other evolutions, has been a long, slow, and often painful process. Primitive man, requiring some explanation for mysterious aches and weakness, sought solace in placing the blame on supernatural influences. This absolved him of responsibility for his own illness. Demonology, and later, Divine Wrath had their vogue as men shifted more and more responsibility from themselves unto God. Later came dim awareness of the relation of epidemics to certain environmental factors (the relation of malaria to swamps) and the appearance of many vague theories of "miasmata," "vapors," and "humors." Though there were glimmerings of the concept of contagion during the terrible epidemics of the Dark Ages, modern etiologic thought began with the epochal discoveries of Pasteur, and the birth of the new science, bacteriology.

Pasteur's discovery that certain diseases were due to invasion by microorganisms or bacteria was quickly followed by Koch's equally significant studies concerning the specificity of the organisms responsible for specific disease entities. Koch declared that the etiologic relation of a microorganism to the causation of disease was not demonstrated without fulfillment of the following conditions: (1) the microorganism is present and demonstrable in every case of the disease; (2) it is cultivated in pure culture; (3) inoculation from such culture must reproduce the disease in susceptible animals, and (4) it must be reobtained from such animals and again grown in pure culture. These postulates of Koch became the basic law of the new science. Feverish research, spurred by the hope that in this vast realm of pathogenic bacteria would be found the explanation of *all* disease, led to many brilliant and invaluable discoveries. One after another, the specific organisms of infective diseases were identified, isolated, and studied. The science of immunology developed as a collateral branch. Diphtheria, typhoid fever, the dread "summer complaint" of infants, plague, cholera, and several other diseases, were quickly controlled, once their infective origin was known. The causative organisms of many other diseases, such as tuberculosis, pneumonia, meningitis, gonorrhea, and syphilis, were also discovered, but effective methods of combating these infections are developing more slowly. Planned chemotherapy appeared with Ehrlich's studies on synthetic arsenical compounds, effective against the spirochete of syphilis. Only in the last few months, the various sulfa compounds and, still more recently, penicillin, have opened new avenues of attack upon the dread coccal infections. Refined laboratory methods have revealed the existence of the still more minute viruses, ultramicroscopic in size and apparently molecular in nature. The viruses belong in that hazy borderline between the living and the nonliving.

But the dreams and hopes of the earlier bacteriologists have not materialized. Invading microorganisms do not cause all disease, and even when they are involved, they are not the sole cause of infective diseases. The concept of specificity, though invaluable in preventing many hasty and erroneous conclusions, also blinded many scientists to the fact that disease follows only when the germ invades a *vulnerable* host. A seed in uncongenial soil does not flourish. It is only in the last few years that adequate attention has been paid to the condition of the host prior to, or during, bacterial invasion. Furthermore, some diseases are in no way etiologically related to infections. The search for microorganisms and viruses as causative agents in cancer has been extensive and painstaking; the results negative. Diabetes, arteriosclerosis, high blood pressure, gout, goitre, and many other so-called "degenerative" disorders arise without the slightest suggestion of infection as a cause.

But the idea of specific causation is not yet dead: a new menace has been discovered in nutritional deficiencies and there are those who now wish to attribute almost every human ill to nutritional defects. They too are doomed to fail, though from their failure

much good will come, for certainly *some* disorders are due to defective nutrition. Science is vulnerable to fads and fashions. We must be constantly on our guard not to be carried away by "fashionable" enthusiasms.

The essential message of this brief and obviously incomplete survey of etiologic thinking in medicine, is that *causation is always a combination of multiple factors.* Nothing happens from just a single cause. This is as true of wars, marriage, explosions, floods, or earthquakes, as it is of disease. It would be immensely beneficial to all our thinking if the singular of the word "cause" were deleted from our vocabularies, and the more flexible term "causative factors" used in its place.

Causative influences are amenable to analysis. They fall under three categories: predisposing factors, provoking factors, and perpetuating factors. These three types of influences are invariably present in the causation of any and all illness, although they are not necessarily of equal importance. Disease is comparable to the long famous illustration of the camel's spinal fracture; it was not just the "last straw" that broke the back of this unfortunate beast of burden, but this last whisp of cellulose *plus* all the previous load, which may have been straw or hay, or figs, or bricks, or harem ladies, or kegs of wine! And in no two instances were these predisposing factors necessarily identical.

We know that almost every adult bears the scars of healed early lesions of tuberculosis in his lungs, though he does not have, nor has he had, clincally active tuberculosis. The provoking factor, the tubercle bacillus, is there. Nothing serious happens because the factors predisposing to invasion are absent. The potentiality of disease, however, remains. Fatigue, intoxications, other infections, or exposures may so lower the barriers of resistance that the latent infection becomes active. Obviously, the condition of the host is equally significant with the presence of tubercle bacilli.

"The cause" of cancer will never be found, nor "the cause" of hypertension or arteriosclerosis. Modern researches are revealing more and more how complex are the interrelationships between constitutional vulnerability, exciting agents, nutrition, infection, intoxications, and perpetuating factors intrinsic in the pathogenesis of many chronic and progressive disorders. Bacteriology will not solve the riddles of chronic heart disease, arteriosclerosis, cancer, or diabetes. Nor will any simple formula, resembling the rigid dicta of Koch's postulates, apply to all cases of any one disease. The concept of specific entities and specific causes has been overworked. The degenerative diseases overlap; the etiology of each and every case, though following general patterns, differs in detail. What we are today is because of what happened to us yesterday. And each of us has had different yesterdays.

A more general appreciation of the significance of the above fundamental classification of causative factors, and greater individualization in etiologic analysis of instances of disease must improve medical practice. The significance of causation lies in the fact that effective treatment, whether preventative or curative, is predicated upon thorough elimination or control of causative influences. We can hardly expect to obtain a lasting cure of a sore heel, if we neglect the nail in the shoe.

EDWARD J. STIEGLITZ

## PHYSICAL ANTHROPOLOGY AT WORK

How big is a big man? How little is a little man? How big is an average man? Big, little, average size must be known in absolute terms, but also proportions and body-types: Long arms or short? Long legs or short? Slender or heavy build? These questions are vital for plane and tank design, for clothing sizes, for oxygen masks, and for many other details involving Aviation and Army personnel and matériel. The answers are being worked out by the Matériel Command at Wright Field under anthropologists: Lieuts. Francis Randall, Albert Damon, Robert Benton, and Dr. Alice Brues.

The initial approach to the problems now being studied was a reflection of the fact that in this war aviation has come into prominence: flying suits and their numerous gadgets had to be sized precisely to fit into restricted spaces; escape hatches had to be scaled to body-size and build; most serious of all, gun turrets restricted personnel size.

It became necessary, therefore, to carry on precise and large-scale anthropometric studies of the physique of the young American males going in for pilots, gunners, and bombardiers.

The first problem successfully attacked was that of types of oxygen-masks. Heads and faces differ from man to man, so that a single standard size and shape could not guarantee the careful and necessary fit. As a result, a series of standard head-forms were established so that within each form-category there could be guaranteed a high measure of safety and precision.

In the study of size and build, standard for turret gunners, the anthropologists gathered not only an impressive array of statistical data, but constructed three lifelike and adjustable plastic manikins that could be sent directly to designers and manufacturers for test-construction jobs. Elaborate studies were carried out to test visibility factors in gun turrets, correlated with positional adjustment and range of vision.

W. M. Krogman

## CONSERVATION OF RUBBER

As the necessity for conserving existing rubber articles continues, it may be helpful to review the properties of natural rubber, particularly those that have a bearing on its deterioration. Those who keep these properties in mind and take care of rubber goods accordingly can greatly extend the useful life of these articles.

Davis and Blake in *The Chemistry and Technology of Rubber* (A.C.S. Monograph 74) point out that oxygen of the air reacts with all soft rubber to bring about its deterioration. As this reaction progresses, the rubber becomes softer, losing tensile strength and elastic recovery properties; then it finally hardens. This reaction is hastened by increase in temperature, by direct sunlight (and to a smaller extent by diffused light), by tensional stresses in the rubber, and by contact with certain chemicals and metals, especially copper and its alloys and compounds.

To demonstrate the accelerative effect of sunlight on the rate of oxidation and consequent deterioration of soft rubber, the writer recently made the following comparative test: One strip of rubber was exposed to direct sunlight for two days; a second similar strip was not exposed to sunlight. Then both strips were placed for the same length of time in a bomb under high pressure of pure oxygen. At the end of the exposure to oxygen, the first strip had become hard and brittle, whereas the second strip was still soft and flexible.

Rubber is not only deteriorated by oxidation but is adversely affected by organic liquids. It is swelled and softened by petroleum oils, turpentine, chlorinated hydrocarbons, dry-cleaning and metal degreasing solvents, most vegetable oils, and some fats.

In recent years the compounding of soft rubber articles has been improved to a remarkable degree so that under favorable circumstances such articles give many years of service. Under unfavorable conditions of storage or use the rate of deterioration may increase tremendously.

The results of the unfavorable conditions just mentioned are commonly observed; for example, hardening of overshoes and raincoats stored in a hot attic all summer, hardening of rubber bands when left stretched around a bundle of papers or becoming sticky and then hard if left in the sun, cracking and failure of rubber boots along the creases after having been stored folded (the outer surface of the rubber at the fold is under tension), failure of rubber garden hose where it is frequently kinked near its attachment to a fitting or where it is hung over a nail, failure of rubber parts on household gadgets where the rubber is in contact with copper or brass parts, or swelling and softening from contact with oils.

Ozone has an exceedingly rapid cracking effect on soft rubber which is under even very slight tension. Ozone forms from oxygen around electrical equipment, particularly high voltage equipment.

Rubber is also subject to failure by "flex cracking," when subjected to continuous or repeated stresses.

One of the most useful of the properties of rubber is its resistance to abrasion. Vogt has attributed this to ". . . its relatively enormous capacity for storing energy. Its energy storage capacity to the point of rupture far exceeds that of any other material."

It is this property which makes rubber unique for tires for motor vehicles. However, tires do eventually wear out, and the wear is the result of abrasion. The rate of wear also will be affected by the chemical factors of deterioration mentioned above.

No authority has been found for the common assertion that tires will deteriorate faster in storage than if they are being used. It is true, however, that tires deteriorate even when they are not being used, and with *improper* storage and care they *may* deteriorate faster than with *careful* use.

The mechanical aspects of care of automobile tires are well known, if not always practiced, but the chemical aspects need greater emphasis. In view of the recognized destructive effect of sunlight on rubber, the writer suggests the use of shields or shades for tires parked in the sun. The shades could be made of fiber board of suitable shape and designed to fold for carrying in the car when not in use. Such shields might be distributed as an advertising medium by local or national advertisers.

The facts outlined above yield this brief admonition: *Keep rubber clean, cool, dark, and undistorted!*

Robert S. Casey,
W. A. Sheaffer Pen Company

## CONDENSER PAPER

So widely has paper been used in the telephone plant, and so well has it performed, that even with the multiplicity of new materials available today, it would be difficult to replace. One of its most important uses is in condensers, those electrical "springs" which absorb energy on rising voltage and give it out on falling voltage. A condenser is essentially two sheets of aluminum foil separated by a sheet of paper; for compactness the three are wound into a roll. Returning to the mechanical analogue, the foils are merely bearing-pads to distribute the stress; the springiness is entirely in the paper. That places three requirements on the paper: it must absorb as much energy as practicable per unit volume, it must waste as little as possible in internal heat, and it must withstand the voltage without breaking down. In the first particular, paper can be greatly improved by impregnating it with chlorinated liquids and waxes, and such paper condensers with aluminum foil electrodes have served the purposes of the telephone plant adequately for a number of years in places where temperatures and voltages are moderate. However, as the demand arose for more compact apparatus and higher unidirectional voltages and temperatures, it was found from laboratory tests that this combination did not provide a comfortable margin of safety. A study was therefore undertaken to discover the causes of failure under these more severe conditions.

Two types of paper have been commonly used for condensers. One is a linen paper, which is chiefly pure cellulose; the other is Kraft paper, typified by the common brown wrapping paper of commerce and which contains relatively large amounts of lignin, pentosans, and ash. It had generally been assumed that linen paper, because of its purity, would perform as well as, if not better than, Kraft paper, but life tests at elevated temperatures, involving continuous comparative measurement of electrical leakage, showed Kraft paper to have a life of four or five times as long as that of linen paper.

On dismantling the condensers after or shortly before failure, decomposed areas were found scattered throughout the paper. These areas were brown and embrittled, giving evidence of partial carbonization, and such areas appeared much earlier in linen paper than in Kraft. Only at much higher voltages do the Kraft papers show decomposition in time comparable to that of linen paper at 120 volts.

To find the reason for the different behavior of the two papers was the problem that challenged research. Here were two simple structures having only three components, paper, impregnant, and electrodes, and both identical except for the paper, yet showing widely different characteristics. The first step was to determine the impurities in the decomposed areas of failed or nearly failed condensers.

To accomplish this, a microchemical technique was employed. A section of linen paper containing decomposed areas was covered with a sheet of indicator paper impregnated with barely alkaline phenolphthalein. The indicator was decolorized in spots cor-

responding exactly to the decomposed areas, demonstrating the presence of acidity. Another sheet of paper containing decomposed areas was similarly treated with a silver chromate indicator paper used in the detection of chlorides. This indicator gave a definite positive reaction for chlorides in the decomposed areas. This demonstration of the presence of acidity and the presence of free chlorides is, of course, equivalent to the demonstration of the presence of hydrochloric acid.

Since the condenser paper used in these studies was extremely low in chlorides (about .004 percent), it was obvious that the source of the chloride ion was the impregnating compound. It was known that such compounds decompose to give hydrochloric acid under the influence of the electric arc or strong ultraviolet light. It now appeared that they would decompose under the conditions existing in a condenser. Strong evidence has been obtained at our laboratories that this decomposition is activated by the aluminum electrodes. The primary decomposition, however, is very limited in rate and amount, and probably of itself would not be perceptibly harmful. The condensers can be heated for very long periods without serious degradation so long as no voltage is applied; when voltage is applied, however, rapid depreciation of electrical properties results. The process of this depreciation is pictured as follows: The minute quantities of hydrochloric acid liberated by the action of the electrodes alone are electrolyzed, aluminum chloride being formed at the aluminum anode. Aluminum chloride is well known to be a powerful agent for the degradation of organic compounds. The most important action of aluminum chloride in the condenser is to further decompose the chlorinated impregnant, providing more hydrochloric acid, which provides more aluminum chloride, and so on until failure. Despite this undesirable action of aluminum, it is in most respects superior to other metals available in foil form at reasonable cost.

Having formulated the above picture, it was time to return to the original question of what makes Kraft paper superior to linen in condensers of the type under discussion. Since the decomposition was a vigorous reaction of the self-accelerating type, it seemed likely that whatever Kraft paper was doing, it was doing during the early stages of the reaction, when small chemical variations might easily influence the whole course of events to follow. Hence, it was apparent that Kraft paper was able to absorb, neutralize, or otherwise inactivate, the small quantities of hydrochloric acid formed in the primary decomposition reaction. It was further apparent that linen paper was either incapable of this action or capable to only a limited degree. The experimental proof of this point was simple but convincing. It was found that if a certain amount of Kraft paper was immersed in any dilute acid, it would neutralize in the neighborhood of 0.06 to 0.10 milliequivalents for each gram of paper, three to four times as much as an equal quantity of linen paper. This experiment has been performed on scores of samples, and although both linen and Kraft papers vary in this property, the level for Kraft papers is far above that for the linen. It thus appeared reasonable to conclude that the papers, by serving as acid buffers, delayed the onset of decomposition, the Kraft paper for a longer period because of its greater capacity.

The acid neutralization by both types of paper was found to be explained by the familiar base exchange concept, the hydrogen of the acid exchanging for chemically bound metallic cations constituting the ash of the paper. The exchange capacity was found to be directly proportional to the ash after a small allowance is made for the inert ash, principally silica.

One might say that at this point the original object of the investigation had been achieved. Had the investigation stopped here, it would simply have explained an interesting phenomenon, but would have been of little practical value. As a matter of fact, the findings discussed above provided both the scientific foundation and the inspiration for further important developments. We were armed with new information concerning the deterioration under electric potentials of paper condensers containing chlorinated impregnants. Could not this information guide us to new methods of producing better condensers?

The various extensions of the original research will not be discussed in detail. It can be stated, however, that this phase of the program was successful; it resulted in condensers that will withstand accelerated testing conditions about 100 times as long as the early linen condensers. The new improved condensers are used by the Western Electric Company in equipment manufactured for the armed forces, on whose behalf these techniques and developments have also been made available to other manufacturers. Considering the severe service conditions to which military equipment is subject, it can be confidently stated that these developments have aided in the reliability of military communications.

D. A. McLean
Bell Telephone Laboratories

## INSECT REPELLENTS

The public has been made so conscious of new insecticides, particularly DDT (p. 154), and of new methods of applying them, especially by the aerosol bomb (p. 342), that many people must think it essential to kill insect pests in order to protect themselves and their belongings against attack. On the contrary, it is not always necessary to slay our six-legged competitors in order to overcome them, and sometimes it is even undesirable to do so if their presence is not annoying. For example, few people would be distressed by the sight of Japanese beetles if it were not for their depredations in turf and on certain trees, vines, garden plants, and crops. If they would confine their diet to smartweed, they might enjoy the aesthetic status of Egyptian scarabs or the "Gold Bug," which they resemble.

We really do not want to kill Japanese beetles; we want to prevent them from eating the plants that we value. For a few years after the beetles were discovered near Riverton, New Jersey, in 1916, entomologists tried to exterminate them by whitewashing the countryside with lead arsenate. But the beetles increased in numbers and spread until it was obvious that they could not be wiped out by insecticides. Gradually the emphasis in chemical control shifted from killing beetles to protecting plants, and in recent years entomologists have been consciously searching for repellents—substances that, when sprayed or dusted upon plants, will prevent the beetles from eating the fruit or foliage. Before the war several promising repellents were found and recommended. Last summer DDT was tested for the first time against the beetles. Fleming and Chisholm now call it "the most effective of the protective materials tested against the Japanese beetle." Its inconspicuous residue did not injure fruit or foliage of peaches, plums, or grapes, and it remained effective longer than the repellents previously recommended. It may seem ridiculous to express regret that DDT also killed many of the beetles, but if it were just a specific repellent on fruit trees and other crops that require pollination, it might not hold a threat for honeybees and other essential pollinating insects, which it is now known to kill. Consequently, DDT will have to be used with discretion for the protection of certain crops.

If anything is more important than the protection of food crops, it is the protection of troops against the attack of disease-transmitting insects, particularly malarial mosquitoes. Recent research has made oil of citronella obsolete. Now we have relatively odorless materials which, when applied to the exposed skin, will stave off mosquitoes for a few hours. Intensive research is going forward to find still better repellents and to make present repellents retain their effectiveness over a longer period of time. When our soldiers are in battle in a malarial country, only a good repellent can protect them completely against their most insidious and devastating enemies.

F.L.C.

# BOOK REVIEWS

## ORNAMENTAL-PLANT PESTS

*Diseases and Pests of Ornamental Plants.* B. O. Dodge and H. W. Rickett. Illustrated. vii + 638 pp. 1943. $6.50. The Jaques Cattell Press.

An overwhelming majority of those interested in growing ornamental plants must be amateurs. They will no doubt prefer to find their information regarding disease and animal pests of all sorts in a single volume. Dr. Westcott set the style, at least for the United States, with her *Plant Doctor* published in 1937.

The difficulty, of course, is that only rarely is any one person qualified to discuss the control of both insects and diseases. Felt and Rankin solved the problem in their *Insects and Diseases of Ornamental Trees and Shrubs* by "each being responsible for statements in his respective field."

Since both the authors of *Diseases and Pests of Ornamental Plants* are botanists, it is to be hoped that the portions dealing with insects and their control were critically read by a competent entomologist. Of this the introduction gives no evidence, and this reviewer is certainly not qualified to judge as to whether such scrutiny was needed. [It *was,* say entomologists.—Eds.]

Any book which is sincerely written must reflect the enthusiasms of the author. This is no exception. Thus we find in Part 1 "Diseases and Pests in General" of a book avowedly "intended for the person with little or no training in botany or entomology" such statements as, "In the asci of the Ascomycetes each nucleus forms a beak from which a system of rays extends; these rays mark the limits of the spore which contains the nucleus." "The asci are formed at the curved tips, known as croziers, of special hyphae in the fruiting bodies, ascocarps." "In this group the mycelium is often marked by what are called *clamp connections.* These resemble both in structure and function the croziers of the Ascomycetes"; these are matters of importance to professional mycologists, but it is hard to conceive of them as interesting to even a very enthusiastic gardener. The net result is that the chapter on insects and other animal pests is much easier reading than that on bacteria and fungi.

On the very first page it is pointed out that many common diseases result from abnormal environment or from poor cultural practices. It is more than once emphasized that new preparations or new mixtures, or control measures to which one is unaccustomed *should be tested in advance* on a few leaves or branches or on a single plant. This is sound advice too seldom given, and still more rarely followed.

The portion of the book (about 500 pages) devoted to the diseases and pests of particular hosts is of course for reference. Reading it would be tedious. For instance, spraying with Bordeaux mixture is recommended no less than two hundred times and the use of lead arsenate ninety-seven. Incidentally this gives some indication of the present importance of these old standard materials. Among the some 600 hosts included, about 75 are listed as being practically free from diseases and pests. This is useful information too often omitted from our works on plant diseases. No doubt some gardeners will be tempted to choose as many as possible of their ornamentals from this list.

A final word may be said regarding the collaboration which has produced the book. The work of each author is clearly stated in the introduction: "The factual basis of the book is contributed almost entirely by the senior author, and is based largely upon his 15 years of experience as Plant Pathologist at the New York Botanical Garden. . . . The junior author is responsible for the organization of the work and for most of the actual writing." Here is a combination of a type which could with advantage be formed more often. It requires no very wide acquaintance among working botanists to enable one to make up a list of men who through wide and varied experiences have acquired a mass of valuable information which has never been made available. Such collaboration as this might have preserved that information for the rest of us.

Neil E. Stevens

## CORNELL'S PINE-LAND ENDOWMENT

*The Wisconsin Pine Lands of Cornell University.* Paul Wallace Gates. xi + 265 pp. 1943. $3.50. Cornell University Press.

THE story of the conversion of Wisconsin pine land into an endowment for Cornell University should interest students of American land policies, of lumber-industry history, and of the political and economic history of Wisconsin. It begins with the Morrill Act of 1862. This Act gave each public-land state 30,000 acres of land for each of its senators and representatives in Congress, and to each of the other states scrip that could be used—but not by the state itself—to acquire corresponding areas of land in the public-land states. The proceeds from sale of the land and scrip were to be used as endowments for agricultural colleges.

The states sold their scrip at what now would seem fantastically low prices. Rhode Island got only forty-two cents an acre, and most of the other states less than a dollar. Wisconsin sold her 240,000-acre grant for $1.25 an acre. New York was the only state east of the Mississippi River to obtain a reasonably adequate endowment through the Morrill Act. This was due to the vision and sustained efforts of a few men—notably Ezra Cornell, who induced the legislature to charter Cornell University and who devised and carried out the plan for using scrip to acquire timberland; Henry C. Putnam, who was largely instrumental in selecting the lands in Wisconsin; and Henry W. Sage and his associates, to whose financial support and good management was due the large profit—more than five million dollars—realized from the project.

Almost half of this book and six of its ten chapters are concerned with Federal and state land policies, the founding of Cornell University, and the rise of the lumber industry and attempts of various interests to gain control of pine timber, mainly on the Chippewa River and in adjacent territory. The rest of the book is an account of Cornell's acquisition and disposal of pine lands and of its attendant trials and tribulations.

Much space is given to the continual conflicts of Cornell's agents with politicians, railroads, and taxing authorities. The hostility of Wisconsin people to large nonresident landowners in general was intensified in the case of Cornell, because it was the largest nongovernmental pine-timber owner in the state, and because "unlike other pine-land owners, Cornell was to do little to further the growth of the state. It simply waited for the expected scarcity of timber which would assure high prices for its lands."

Cornell's investment was subject to the usual hazards of timberland speculation, such as uncertainty of future timber values, dishonesty of local land agents and timber purchasers, forest fires, loss by windstorm (one storm in 1872 blew down 200 million feet of pine in Chippewa County alone), and timber stealing, which became "a major occupation in Wisconsin." Besides, it was the policy of local residents and taxing authorities to finance improvements and government mainly by taxing lumber companies and nonresident landowners. As to whether this was attributable to selfishness, mismanagement, extravagance, and corruption, as Dr. Gates implies, opinions may differ. Cornell's tax bill on 500,000 acres of land (including between 50,000 and 100,000 acres of agricultural land), much of which was held for 15 to 25 years and some for more than 40 years, amounted to less than $650,000, or not quite one-tenth of the receipts for land and timber.

The author admits that: "A subsequent generation was to regret the destructive cutting practices of the lumbermen who destroyed irreplaceable resources in a generation, and it was to regret too the zealous work of the land companies which produced many submarginal farms and led to the settlement of areas which have since had to be abandoned. Cornell University had its share of responsibility for both misfortunes. . . . While benefiting to the amount of $5,000,000 from its investment in Wisconsin pine lands, Cornell, like other lumbermen speculators, left the pinery counties nothing to compensate them for the wealth which had been taken away."

The reader may feel disappointed that the book tells practically nothing about the exploitation of the pine timber and the subsequent use of the land. It would be interesting to know the sequel to the history of Cornell's land speculation: What is the pres-

ent condition of the lands and the forests? Who owns them? How many permanent residents and what industries do they support? What became of the lumber companies that operated on them?

It is also interesting to speculate on what might have happened if the University had held its pine a few years longer, or had established its school of forestry thirty years sooner than it did. The 400,000 to 450,000 acres of pine, managed as a sustained-yield forest, might have returned a far larger income to the University and at the same time could have been of lasting benefit to the people and State of Wisconsin.

W. N. SPARHAWK

## PHYSICS TELLS WHY

*Physics Tells Why.* Overton Luhr. Illustrated. ix + 318 pp. 1943. $3.50. The Jaques Cattell Press.

AN alert human mind persistently asks, "the why of things." In selecting "Physics Tells Why" as the title of this book, the author has emphasized the primary characteristic of physics, the most fundamental of all the sciences. The purpose of the book, as explained by its author, is to offer trustworthy explanations and interpretations of everyday physical phenomena for those who find pleasure in understanding them. Rigorous proofs are omitted. Emphasis is placed on lucid and intimate descriptions without resource to mathematics or technical language. Physical concepts and observable phenomena are stressed. The familiar subdivisions of classical physics—mechanics, energy, heat, electricity, sound, and optics—are discussed with unusual clarity and simplicity. In making selections from the field of modern physics, preference has been given to applied electronics. There are elementary discussions of such topics as photoelectric cells and their applications to burglar alarms, talking motion pictures, and television; thermionic tubes and their uses as generators and detectors of radio waves; X-rays and their applications in medicine, dentistry, and industry. Some suggestions are made with respect to probable developments in the field of physics. They are tentative and subject to revision on the basis of new discoveries. Novel and original illustrations by Miss Ruth C. Schmidt stimulate interest and help to clarify explanations.

Those who are interested in knowing whether they have mastered the fundamental physical principles sufficiently well to apply them to specific problems will find a series of interesting questions and answers in the back of the book. An attempt to answer these questions will furnish a profitable exercise. This book should stimulate a wider interest in everyday physical phenomena; provide profitable reading for intelligent laymen; and encourage students endowed with enough curiosity about physical phenomena to make physics a scientific career. It can be very appropriately recommended as supplementary reading for college and secondary students taking a beginning course in general physics. This book, which will make the meaning and importance of physics in everyday life more widely appreciated, has been very correctly included in the Humanizing Science Series of The Jaques Cattell Press.

ALPHEUS W. SMITH

## INTRODUCTION TO PSYCHIATRY

*Introduction to Psychiatry.* W. Earl Biddle and Mildred van Sickel. Illustrated. xiii + 358 pp. $2.75. 1943. W. B. Saunders Co.

THIS is, as the authors indicate, an "introduction to psychiatry." It is an ideal book for the student nurses just beginning to study the subject. The first half of the book deals with special psychiatric problems such as destruction, suicide, personal hygiene, patient's nutrition, etc., which the student will meet as soon as she enters the psychiatric ward. The basic terminology and symptomatology, used throughout the remainder of the book, are introduced here in simple, easily understood language. Forms of therapy significant to the care of the mentally ill are described and elaborated upon.

The nursing procedures which are illustrated, although limited in number, clearly portray the method used. The procedure for the pack is especially easy to follow. The importance of limiting hazardous articles to patients is stressed by the use of pictures showing the various weapons made by them from seemingly innocent materials.

The second half of the book deals with the

psychoses, and the manner of approach to each is interesting. The authors give a brief, concise description of the disorder, including the symptomatology; next, they present a typical case to illustrate; this they follow with a short discussion of treatment, prognosis, and prevention.

The questions at the end of each chapter cover each entity quite thoroughly and indicate to the student where the emphasis should be placed.

Although most of the definitions of technical terms are to be found in the chapter on symptomatology, it is unfortunate that there is no glossary in the book.

If the student grasps the major portion of the book she will have gained a good insight into psychiatric disorders and will have a more sympathetic appreciation of the care of the mentally ill. She likewise will have a better understanding of her own problems and of those of her associates.

DOROTHY MORRIS

## EDUCATION FOR AMERICAN DEMOCRACY

*Education for American Democracy.* James L. Mursell. 528 pp. 1943. $3.75. W. W. Norton & Co.

IT is not surprising that there are vigorous and often conflicting arguments about education in America. That is an expected and a necessary feature of a democracy. Since the various aspects of education constitute the chief means of developing citizens, and since a democracy has committed itself to allowing a hearing for every intelligent voice, education has been and will continue to be argued about so long as the democracy tries to improve itself. Furthermore, educational philosophy, organizations, and procedure deal with such vast areas and resources, so many learners and so many teachers, that desirable changes come slowly even though leading thinkers may reach approximate agreement about possible improvements. The one thing which the majority of citizens of America will not relinquish is their belief in democratic processes, and they insist on applying these processes to their education even though the many assertive voices of advocates sometimes produce confused outcomes. If the whole mass movement is advancing, that is good. If no advancement occurs, or if there is retreat, it may be asked if democratic education is succeeding.

Professor Mursell attempts the needed task of setting down the origins and development of American public education. He shows why and how there must be some such plan as ours, lest there be no democracy. The colonial schools of Europe were tried here. Exclusive schools for those who could or would meet the obligations were tried. Training for professional life, at the outset was in no sense a part of a general program of education. A general program of education came into existence, negatively, as a protest against undemocratic tendencies, and, positively, as a procedure which is inherent in the promises of the very essence of democracy. No one claims that we have fully discarded some of the elements of exclusive control. Conventional procedures and control of funds have been undemocratic. Indeed, it sometimes seems that control by educational "vested interests" occludes our approaching realization of the democratic education that is to be. Funds for support are essential and too often those who provide the funds control their uses. And the struggle to secure funds too often occupies the so-called thinking of would-be educational leaders. Our democratic faith must often be called into service, lest occurrences at times may unduly retard our progress. It is with most satisfying documentation that the author of this comprehensive volume regularly places before the reader the development of our present educational system. Conflicting ideas with their advocates are tied into the steadily developing story, nowhere better told.

Examples must be brief and but few of the many important topics may be used. The elective system in colleges is clearly stated within four pages including the claims of six representative persons who have given it much thought. The conclusion is that "the principle underlying the elective system is that of intellectual freedom for mature and serious persons who know what they want to do and who are therefore able to make judicious choices." A narrow, prescribed, or classical program can be maintained only by a system of prescribed examinations, and

such a system is the "practical politics of the 'great tradition'."

The Committee of Ten (1893) came at a time of greatest transition in American thinking. Its extensive and detailed reports, now often severely criticized, tried to hold the ground gained while urging education to move forward. The enforced compromises allowed subject-matter specialists to control the report. Each one prescribed for his subject a scope and content beyond possible use. They outlined curricula so extensive that no one pupil could possibly do all the requirements. But pupil elections were allowed which permitted him to miss most of the courses, and for those the courses ceased to exist. It took secondary schools a very long time to face the problems of true reorganization of subjects. Not yet is it fully recognized that most secondary pupils do not possess the qualifications stated in the principles of election as observed in the preceding paragraph. Even so, it seems likely that no national report has had more effectively helpful results than the "Report of the Committee of Ten." The author of this book presents an excellent statement of that report.

The "humanization" movement in elementary schools had its first practical chance in an educational experiment in the public schools at Quincy, Massachusetts, inaugurated by Charles Francis Adams and Colonel Francis Parker. They buttressed their experiments by definite proof that conventional procedures did not produce the results claimed for them. Added to great personal freedom for pupils there was introduced the plan of using and stimulating first-hand pupil experiences out of which to develop arithmetic, language, geography, drawing, modeling, and free talk by the pupils. Colonel Parker's goal was not only to improve scholastic efficiency but also to produce a markedly different kind of school life. This reviewer once heard Colonel Parker when he was under severe verbal attack by an educational "stand-patter." The critic closed by vehemently asking "Colonel Parker, just why did you do it?" The appropriate reply to an audience which unfortunately regarded a good laugh as good argument was, "Oh! I felt so sorry for the little duffers." Colonel Parker's long life of advocacy of freedom and of experience as basis for school work was the foundation of much recent work whose advocates sometimes seem not to know this origin. The account then follows the whole series of stages in building the present educational policy, if "a policy" is a usable expression. The author would have education face the task of constructing "a new social order," but properly believes that this must come through steady development, not cataclysm, based upon what is, and guided by the best tendencies as now discernible.

An extremely important, comprehensive, discriminating, and lengthy chapter deals with "The Human Problem of American Education." The problems of youth, ages 16 to 24, now insistent, with the return of peace "will most certainly be upon us again in aggravated form, for it is one of the perennial and inescapable problems of an industrial age." The answer to this and other human problems must be sought through *"the democratic way of life itself."* The different solutions for different groups of problems will require more thorough and searching thought and experiment than have yet been used. These problems are then considered as they pertain to nursery, kindergarten, elementary schools, secondary schools, and higher education including adult education. Even more significant are the discussions of curricula, administration, and teacher training.

This reviewer intends to convey the impression that Professor Mursell's book is unusually factual, serious, substantial, and far-reaching. It is a treatise much needed by all who are or should be interested in education.

OTIS W. CALDWELL

## DEVELOPMENT IN ADOLESCENCE

*Development in Adolescence.* Harold E. Jones. vii + 166 pp. 1943. D. Appleton-Century.

"JOHN has been handicapped by unhappy relationships within his family; economic stress; ill health; visual defects; an inferior physique; delayed maturity; a certain obtuseness in social contacts; lack of athletic abilities; and lack of abilities to win goals which he most desired in connection with a

strong desire for popularity and social esteem."

Through Dr. Jones' report, abstracted from voluminous data accumulated by the California Growth Study, we follow John's development from the sixth grade to his first year as a college freshman. This cautious and well-written book may be described as a broad comprehensive case study embodying the entire gamut of psychological techniques from loosely subjective comments by teachers to such "objective" methods as photo-recorded galvanic reactions to emotionally potent stimuli.

The study opens with a sociological (and somewhat social-workerish) description of John's home environment and neighborhood. A series of word pictures follows, taken through the more or less sharp lenses of teacher comments and ratings, Reputation Test ratings by classmates, direct observation reports by trained observers, ratings of social effectiveness, physiological and anthropometric measurements, psychomotor tests, interest-attitude scales, and such projective techniques as the Murray Thematic Apperception test, voice record analysis, and the ubiquitous Rorschach test. John's evaluation of himself is determined by means of self-ratings.

The composite result of these flashes reveals a personality in the process of learning to function acceptably. The difficult experience of growing into maturity is highlighted in a more persuasive fashion than is possible by means of the conventional group study.

The methodology of the California Adolescent Study deserves high commendation. Individual tests and scales are always evaluated in terms of standard scores based upon the responses of the total age group from which the individual study was taken. None of the tests are over-interpreted and facile simplification of the many-facetedness of adolescent change is avoided. The inadvisability of artificially segregating discrete traits and treating them as entities is stressed throughout the book. No single technique is given pre-eminence over the others. As the author wisely remarks, "the course of wisdom is to use more than one method in combination with other data from the life history, rather than to rely upon interpretations based on a single approach."

Parents of adolescents and all those who work with children in this age range will be encouraged by the evident tendency of the maturing personality to achieve a measure of adaptation to the social environment despite the presence of unfavorable behavioral symptoms during the formative years. As the author remarks at the conclusion of his study, "So marked an upturn in John's personal fortunes is evidence not only of the toughness of the human organism but also of the slow, complex ways in which nature and culture may come into adaptation." Teachers and counselors will also find in this book a sympathy-compelling picture of the stern requirements for successful membership in the adolescent social structure.

Dr. Jones has resisted the temptation to indulge in an elaborate theoretical interpretation of the total personality structure of his subject, thereby paying more than lip-service to the complexity of the whole personality. At times one wishes that certain parts of the book had been presented in greater detail. This is especially true of the section which deals with drives, where there is just enough to whet the appetite for more.

One is impressed by the extent to which results obtained by diverse techniques tend to corroborate each other. This should give pause to those who decry pencil-and-paper tests and questionnaires in favor of projective techniques solely. Dr. Jones is aware that there are many mansions in the house of personality and that many keys are required to unlock them.

This book is recommended for its sound approach to the problem of adolescent development. It should prove valuable as supplementary reading in courses on adolescent psychology. A good index facilitates ready reference to specific topics.

FRED BROWN

# COMMENTS AND CRITICISMS

### Humility

Direction of research should, to my way of thinking, be essentially informal; and I believe that the facts of its most outstanding successes will bear this out. Recently, I was especially reminded of this by the article in this journal for April, 1944—"Using Hydrogen to Save Coal"—describing the development of the hydrogen-cooled electric generator. The copy of the original memorandum sent to Chester W. Rice by Dr. Willis R. Whitney, Director of the Research Laboratory of the General Electric Co., might well be read by any executive financially responsible for an industrial research institution. With the permission of *The Scientific Monthly,* I would like to quote its first few lines:

"Dear Chester:

Could I create an interest for you in a series of fool stunts which have, I think, the promise in them of some useful outcome. . . ."

Written in longhand and undated (save for a caption signed by Rice: "Received about Feb. 21, 1921") this memorandum in its opening words exemplifies the delightfully informal spirit of true research—no hint of compulsion, of pontifical authority, of superior wisdom—just an interesting technical idea breathing true humility, from one friend to another. But what important industrial developments flowed from it! To quote again from the author of this article, Philip L. Alger: ". . . the end result of Dr. Whitney's note is that hydrogen cooling has become standard for nearly all large steam turbine driven generators in the United States."—George V. Caesar.

### Heaviside

The following note may be of interest in connection with Perrine's paper in the January issue.

When the A.I.E.E. tendered a dinner to Marconi on the occasion of the first transatlantic radio message, Marconi recited a passage from one of Oliver Heaviside's papers that put him (Marconi) on the right track. As I recall the passage it ran something like the following: "Any method of transmitting messages without the use of guides must fulfill the conditions of a telegraph circuit." So simple as that!

Again when Pupin was tendered a dinner on the occasion of the first successful transcontinental telephone message, he read aloud from a paper by Oliver Heaviside that put him (Pupin) on the track of the solution of the long distance telephone problem.

I attended both dinners and made notes. Somehow or other Heaviside has never been given full credit for his remarkable work and his brilliant mathematical solutions of many electrical communication problems long before practical applications came into use.—Bassett Jones.

### C. P.

Commenting on "War Effort," second item, p. 331, I regret the introduction of crudeness and vulgarity into anything that goes into so highly reputable and in all so worthily dignified a journal as *The Scientific Monthly.* I refer to "by golly" and "darn." They are plain indecencies in print and do not have to be used. The author just had to show his smartalicky way of tiding over his embarrassment, having been criticized. He was smart: he chose to draw attention to his language rather than to himself. Please keep even your letter department *clean.*—P. M. Glasoe.

### Philornithy

The merit (if any) in publishing such an inept case of social reasoning(?) as the so-called "parable" of Alexander Skutch in the April *Monthly,* lies in the opportunity afforded to use the page of criticisms to refute this all too prevalent pacifism in social philosophy. (But of course these notions should be constructively refuted by offering, at much greater length, a scientific alternative in the attempt to establish peace on earth and good will among men.)

The Kingdom of Heaven may be like unto a mustard seed, but that does not make man a flycatcher. Nor is man striped until caught and punished for stealing the other fellow's possessions! The alleged analogy drawn by our naturalist friend seems a decidedly forced attempt at rationalization of a Pharisaic philosophy of pacifism, and is correspondingly mischievous, not to say iniquitous. The author may know his flycatchers, but he does not know his men or even his New Testament wherein the parables are typically drawn from human rather than from animal conduct.

Even the facts cited relative to the allegedly pacifistic species of flycatchers are ignored in the quite unwarranted analogy drawn with human affairs; for within their own species the unstriped flycatchers exhibit no such eleemosynary "philornithy" as the author, with globalonial zeal, advocates among men. On the contrary they cannot "go in search of another area" when parasitized by the striped species because "in all liklihood they would find it already in possession of another pair of their kind, who would resent (sic!) their intrusion." How un-

christian (?)—or at least, how sad for the "Utopian good-fellowship" of the author's tropical paradise!

Having been educated as a student of parasitism I have never before encountered such a quixotic notion as that which says that "the prosperity of the highly gifted" (?) host "is linked with the welfare of the deficient" parasite. The *gift* seems to me to be on the side of the parasite which has found a way of deception to enslave its victim by decoying it from its nest to where it cannot see how it has been despoiled of its eggs and is left to suppose that the nest has been pillaged by a snake or weasel and so has become untenable.

Though not too well established as yet, it is a developing virtue among men that though some may still be fooled all the time, and all may be fooled some of the time, science is supposed to come to the rescue and prevent us from fooling each other all the time. "Ye shall know the truth, and the truth shall make you free!" Eternal vigilance is the price of liberty!—Alden A. Potter.

I envy you "A Parable for Peacemakers" by Alexander F. Skutch in the April issue of *The Scientific Monthly*.—Richard W. Westwood, Editor.

### Heads, Tails, and Chance

According to "the laws of chance" a coin when tossed many times will fall as often heads as it does tails, approximately. Under ideal conditions, according to these "laws," the ratio will be exactly 1 to 2. To "prove" this, mathematicians and others have sometimes devoted themselves with high scientific seriousness to the business of tossing coins for thousands and thousands of times, an example being Stanley Jevons's run of some 20,480 throws, mentioned in his *Principles of Science*. If Jevons took two seconds per throw, which would mean rather fast work, then he was at it for the equivalent of some fourteen eight-hour days; which today fills a person with wonder.

I believe there is no recorded instance of an equality of heads and tails, no matter how many throws were made. The experimental results seem to be wholly inconclusive, and we might say irrelevant, so far as "the laws of chance" are concerned, for we find it strictly maintained that "in the long run"—a run of 20,480 not being long, evidently—the anticipated equality will be realized. Professors Cohen and Nagel in their admirable *Introduction to Logic and Scientific Method* say that "from our knowledge of mechanics" we may "infer that the forces making a penny fall head are bound to balance those which make it fall tail" (p. 167). It is regrettable that they do not tell us how we know this. Mechanics or no mechanics, there is a begging of the question.

Since the equal division does not occur in experience, we may presume the meaning of "the laws of chance" to be that it will occur under ideal conditions. What are the ideal conditions contemplated? Let us say they are an ideal tosser, an ideal medium, an ideal receptacle, in addition to an ideal coin (one homogeneous and symmetrical). This will allow ideal tossing and ideal falling, which seems to mean constancy in both. But under these conditions we should indeed never see the equal division; all that we could expect would be that the side which showed after the first fall would show after every subsequent fall.

This may seem scandalous, yet the only alternative under the terms given is self-contradiction. For we should have to suppose that the effect $E$ of conditions $C$ was now not $E$; which is intolerable.

It might be objected that this presumes the tosser to hold the same side in the same position at every toss, hence that he only needs to change sides. But in that case the result would be a function of such change, and not one determined according to "laws of chance."

A further objection might be that the ideal conditions do not include but, if anything, exclude identity throughout—identity of position in each toss, of propulsion, trajectory, etc. But if they do not include these, they admit caprice, or the like; which means they are scarcely ideal.

Or one might argue that ideal conditions mean only that all bias is excluded and the phenomena are left free. But to suppose that the result will then be equality of heads and tails is nothing other than substituting naive presumption, or "equal distribution of ignorance" (Boole), for a rational solution. It is equivalent to supposing that a given event will always happen though a positive cause of it be not affirmed.

The assurance with which mathematicians and statisticians hold that heads must equal tails is hardly to be taken as so crude a presumption as this, we may suppose. It seems to have a demonstrative ground. What then might its premise be? The proposition in question, let us notice, is: A homogeneous, symmetrical coin freely tossed a large number of times under constant conditions will fall equally heads and tails. This clearly requires the premise (if it is a deduction as supposed) that all homogeneous, symmetrical bodies fall this way. Now we hardly know this latter from observation, since we do not observe, or know that we observe, all homogeneous, symmetrical bodies. So we must have it *a priori*. Not much analysis would be needed to show that it arises from logical principles, or at least that it is consistent with them; namely, the principles of contradiction and identity.

But logical principles say nothing of the physical world. They cannot tell us that nature will always

obey them, nor that nature will at random always lay out the conditions necessary to produce an equation of heads and tails. Still less can experience tell us anything so wonderful. We have no positive ground for supposing it, and the absence of such ground, or simply ignorance, is certainly no warrant for its assertion.

The supposition concealed in the paradoxical term "laws of chance," that a total absence of determination guarantees a balance of events, or some fixed ratio amongst them, is both question-begging and self-contradictory: the first self-evidently, and the second because absence of determination is certainly not determination.—Peter A. Carmichael.

### Peccavimus

Unless the editors wish *The Scientific Monthly* to become a journal of controversy respecting the ethics and intelligence of scientists, it would seem that they ought to examine manuscripts submitted to them with sufficient care to prevent the publication of plain distortions of the facts. The reference is to a recent article by George A. Lundberg ("Scientists in Wartime," *The Scientific Monthly*, 58: pp. 85–95). "My point is," the author says, "that the prestige of scientists is not increased by their tendency alternately to ride the bandwagon and then, after the parade is over, to appear conspicuously in the ranks of the debunkers." He refers to "the unbelievable gullibility of many scientists," and others, although one might suppose that what is "unbelievable" need not be a matter of concern to anyone. Having little interest in the "debunkers," I need not consider that critical generalization. He mentions several people by name and happens to give a good deal of space to my article ("What Are the Fittest," *The Scientific Monthly*, 55: pp. 487–494; 56: pp. 62–70) published a little more than a year ago. From this he quotes at some length with a number of significant gaps. I should not object to his exposure of errors in my article had he found such as are undoubtedly there. It is in order, however, to protest at the gratuitous addition of errors by the use of comments that, while ostensibly descriptive or interpretive, are actually something else. One wishes to avoid the term *misrepresentation* but no other word seems applicable.

No defense is now offered for any position taken in my article, because no position taken therein has been attacked. It is only in order that errors may not go by default that attention is directed to the explicit misstatements. The intent to misrepresent is not charged or assumed. The critic in question could have been moved by some emotional reaction leading him to envision nonexistent hidden meanings. A few illustrations of what seem clearly to be irresponsible distortions will suffice.

The writer in question charges me with *scoffing* ("scoffs" is his word) at the idea that, to have world organization, we must first educate the people. It seems fair to say that this is simply untrue. The word "scoff" has a definite meaning recorded in the dictionaries. To say, as I did, that war will be educative as to the undesirability of international warfare is the reverse of derision of the significance of education. To point out that great reforms sometimes precede rather than follow general popular demand and meet with virtually universal approval is not jeering. I happen to think that the ideal in democratic administration is to anticipate *sometimes* rather than to follow *always* compelling popular demand. A professional political scientist is entitled to regard that view as unsound and based on inadequate information; to call it *scoffing* is merely to evade argument and attempt to discredit by vocabulary: is that fitting behavior for a "scientist in wartime?"

After a series of broken quotations from my article he makes the most irrelevant and misleading comment that "most social scientists would content themselves with pointing out that the implicit assumption in the above reasoning is that Germans and Japanese are carriers of war just as mosquitoes carry the germ of yellow fever." Then he blandly dismisses his assumption, obviously *not mine*, with the words: "In view of the more elementary facts of history, no informed person will want to continue the discussion beyond this point." I have too much respect for social scientists to believe that they would carry the discussion even *to* this point. Anyone who reads the original article dispassionately must see that the argument was simply this: some say wars are inevitable because we have always had them; it was once thought that plague and yellow fever were inevitable because we had always had them; it has been found possible to control yellow fever and bubonic plague; and it may well be possible to control the allegedly inevitable addiction to warfare. If one chooses to suspect that such elementary reasoning, intelligible to third grade pupils in school, must have some subtle implication, one is, of course, entitled to nurse one's own suspicious; but to strain that simple analogy so far as to relate Germans and Japanese to the "carriers of disease" is not sensible. Professor Lundberg must take the responsibility for that assumption from the words he quotes.

When he ascribes to me the doctrine of "the extermination of all who oppose the would-be exterminator's ideas as to the proper solution," he merely soars beyond the loftiest realm of fanciful imagination. It is almost absurd to reply to a misrepresentation that would be libelous if it were not so fantastic. Like almost all Americans, I dislike war; nevertheless, with all but a few thousands of our compatriots, I believe that when attacked we must fight back, and fight back with fullest possible

power. I said: "we are now confronted with war and the makers of war, and the only proper action, whether one likes it or not, is to go just as far in annihilation, or in imposition of 'durance vile,' as is necessary to create a greater impotence for warfare and a greater distaste for war than some nations have thus far had." "*Just as far . . . as is necessary*" are intelligible English words. One may not like the expressions or the basic idea, but to call this a "doctrine" of "the extermination of all who oppose the would-be exterminator's ideas as to the proper solution," is unjustifiable if not irresponsible abuse of the English language. Although regarding war as the poorest possible means of settling disputes, I, with millions of others, give approval to what the United States, Britain, Russia, and China are now doing on many fronts. If such a position is "amusing" (his word) to Professor Lundberg, the question arises as to whether his sense of humor is somewhat out of the ordinary or whether he does not understand what was written. If he disapproves what is in active progress on many fronts, his recourse is not to me but to the leaders of war activities.

Other examples of misrepresentation could be included but these are sufficient. It is possible that Professor Lundberg's apparent emotional reaction is derived from my perhaps over-bold prediction (written and spoken publicly in April, 1942, long before Casablanca and "unconditional surrender") that peace will not be based upon compact *with the vanquished;* he quotes only in part. He asks himself the rhetorical question: ". . . do I then advocate appeasement and compromise in the present war?" And he concludes that "appeasement and compromise will occur because there is, practically speaking, no alternative." No one would question his right to a belief in appeasement and compromise, whether he used these words in the sense in which they are ordinarily understood or only in a highly academic sense; nor need one doubt his right to devote several paragraphs to the attempted education of scientists and journalists as to the rules of the scientific game. We may all endorse his dictum that "the scientist, like any other citizen, should do his utmost to change the rules if he feels like it, but, while doing so, he must conform in general to the accepted rules or he will find his chance to do really effective work of any kind seriously curtailed." On the other hand, it is not out of place to suggest that Professor Lundberg himself, in writing regarding scientists, should follow the accepted rules about correct reporting.—R. E. Coker.

### Touché

Dr. Byrne J. Horton's criteria for professions (*The Scientific Monthly*, February, 1944, page 164) which you state resulted from contemplation of the characteristics of the professions of law, medicine, theology and advanced teaching, certainly apply aptly to engineering (not mentioned) and to medicine, and more completely to these two than to the others named. In fact, it appears to the writer that, taking into account the terms "well-established and socially accepted scientific principles" and "scientific technique" used by Dr. Horton in Criteria 1 and 5, all would be excluded except engineering and medicine.—C. K. Harvey.

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